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TWENTY-EIGHTH ANNUAL REPORT

of

Pasture Research

in the

Northeastern United States
University Park, Pennsylvania

1964

FOR ADMINISTRATIVE USE ONLY

1964

Twenty-eighth Annual Report

of

Pasture Research

in the

Northeastern United States

U. S. Regional Pasture Research Laboratory
University Park, Pennsylvania
Forage and Range Research Branch
Crops Research Division,

Northeast Branch
Soil and Water Conservation Research Division,
and
Grain and Forage Insects Research Branch
Entomology Research Division
of the
Agricultural Research Service
U. S. Department of Agriculture

and

The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

- - - - -

Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition to some institutions outside the Region where grassland research is a major interest.

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INTRODUCTION

This report, the twenty-eighth in the series, is intended for the use of personnel engaged in forage research in the Northeastern States. It contains brief summaries of progress during 1964. Included are reports of research at the U. S. Regional Pasture Research Laboratory, and at Experiment Stations of the 12 Northeastern States. Also included are brief, and in some cases, condensed reports of some regional technical committees. Thanks are due to the chairmen of the Technical Committees, to the Collaborators, and to others for assembling and editing these reports.

There were some changes in personnel at the Laboratory during the past year. R. R. Hill, Jr., with degrees from North Carolina State and Cornell Universities, came to direct the genetics research on alfalfa. G. A. Motter, Jr., assistant with eight years service resigned. Early in 1965, S. R. Wilkinson, who had directed the research on soils since 1960, left to take another government assignment in Georgia. R. R. Robinson, formerly of the Laboratory staff, has returned to direct the soils research in addition to his responsibilities as soil management investigations leader in the Soil and Water Conservation Research Division. Helen D. Hill, cytogeneticist since 1938, retired early in 1965. Also retired during the past year was Mason A. Hein, Assistant Chief of the Forage and Range Research Branch at Beltsville, who had been closely associated with the Laboratory since its founding in 1936. Newly appointed officials in charge of forage research for the USDA are A. A. Hanson, Branch Chief, and K. W. Kreitlow, Assistant Branch Chief. Both are former members of the Laboratory staff.

Members of the Laboratory staff have been active in scientific meetings. A. W. Hovin and R. R. Hill, Jr. presented papers at the national meetings of the American Society of Agronomy. J. T. Sullivan gave a paper at a joint symposium sponsored by the American Society of Range Management and the American Grassland Council. J. H. Graham, R. R. Hill, Jr. and R. C. Newton gave reports at the Alfalfa Improvement Conference. K. E. Zeiders attended the meetings of the American Phytopathological Society. Early in 1965, J. H. Graham attended and gave a paper at the Ninth International Grassland Congress in Brazil. Four members of the staff are members of Northeastern Regional Technical Committees.

During the year, the Laboratory lost the use of an area near the Laboratory building which had been used for small plots and for weather-recording instruments. The University reclaimed this strip of land for the erection of a Computer Laboratory on the site of the old rose garden. A small area is currently being used for weather-recording but its future use for this purpose is in doubt. The land which the Laboratory has now for plot work is five miles away.

The year 1964 was the fifth consecutive year with below-normal precipitation at State College. The total for the year was 8.43 inches below the 30-year average of 38.70 inches. Eight of the 12 months had lower than average precipitation, beginning in May and continuing the rest of the year. Only in April was precipitation above normal. From late May to early August, and again in late September until freezing, there was less than ten percent available moisture in the 2"-16" soil layer under sod. The mean annual temperature, the degree of sunshine, and the wind velocities were near normal.

RESEARCH AT THE PASTURE LABORATORY

GENETICS, PATHOLOGY AND ENTOMOLOGY

Alfalfa

Polycrosses of Disease Resistant Alfalfa Clones

The development of clones resistant to several foliar diseases has been described in previous Annual Reports (1962, p. 3; 1963, p. 3). Yield and other data were obtained from polycross progeny of 65 of these clones at four locations, Pennsylvania, Minnesota, Utah, and Nebraska. Cayuga and Vernal were included as checks. Progenies were found which were significantly better than the average of Cayuga and Vernal for hay yields for all cuttings at Pa. and Minn., recovery after cutting at Pa., downy mildew resistance at Utah, and bacterial wilt resistance at Minn. Hay yield means averaged over cuts and locations were not significantly different, probably due to large interactions of progenies with cutting and location effects.

Chaff-seed yield correlations were obtained from the Utah data. Values for total, entries (after blocks), and entry component (genetic) sources of variation were 0.83, 0.80, and 0.79, respectively. All correlations were highly significant. Stand differences at Utah were large, but correlations adjusted for stand did not differ very much from those given above.

Selections from Connecticut with Resistance to Bacterial Wilt and Crown and Root Rots

(In cooperation with D. D. Wolf, Connecticut Experiment Station, Storrs).

History of the Connecticut clones and experiment in progress were given in a previous Annual Report (1963, p. 3). Survival notes were taken on a 1962 planting at State College (14-plant rows). Progenies of the Connecticut clones averaged 12.2 plants per row; DuPuits — all dead; Narragansett — 3.0; and Vernal 8.5. The seedlings were inoculated with bacterial wilt organism before transplanting to the field.

Recurrent Selection for Resistance to Common Leafspot in Alfalfa Mass-Selection Populations MSA and MSB

The results of three cycles of phenotypic recurrent selection in two pools of alfalfa germ plasm were evaluated in the same environment (see 1963 Annual Report, p. 3 for history). Selection was effective in all cycles

of Pool A, but not with the third cycle of Pool B. The greatest response to selection came in the first cycle. The within plot variance of Pool B was significantly greater than that of Pool A for all cycles.

The frequencies of 8 seedling mutants were followed during the selection program. The frequencies of some mutants increased, others decreased, and some did not change with cycles of selection.

Seeds from the last cycle of selection were sent to Beltsville, Md., where resistance to bacterial wilt will be added to the pools.

Screening for Insect Resistance

A procedure has been developed for screening alfalfa populations for resistance to spittlebug during the winter. Oats are seeded in flats during March or April, allowed to head and cut back to a height of about 4 inches. The stubble is exposed to adult spittlebugs during late-September and October. The flats are stored in cold until about December 1. Plants to be evaluated for resistance are transplanted into the flats and the number of nymphs on each plant counted in about 7 weeks.

It is hoped that methods for screening for leafhopper and alfalfa weevil resistance during the winter can also be developed. If this can be done, a selection program for the three characters will be started in the fall of 1965.

Twenty plants of 407 alfalfa introductions were transplanted to a field near State College, Pa. in August. These plants will be observed for possible resistance to the alfalfa weevil.

Inbreeding in Alfalfa

One hundred plants of MSAW-4 and MSBW-4 (bacterial wilt resistant material from Beltsville, Md.) were self-pollinated. Hopefully 6 generations of inbreeding can be accomplished with at least 6 clonal lines in each pool. If this is possible, the effects of inbreeding on the performance of single crosses, double crosses and synthetics will be investigated.

Inheritance Studies in Alfalfa

The segregation patterns of three mutants in autotetraploid alfalfa are being investigated. (1) A tumor produced by insect injury or inoculation with insect juices (see Barnes and Newton, 1963. Nature 199: 95-96). S_1 and F_1 generations suggest a large number of alleles or large environmental effects.

The tumor inheritance study will probably be discontinued. (2) A chlorotic mutant characterized by pale-green or yellow stem tips. Normal green color develops as the young tissue matures. S_1 and F_1 generations suggest recessive alleles at 2 loci. (3) A dwarf. S_1 and F_1 generations suggest recessive alleles with differential pollen tube growth or gamete survival. F_2 and F_3 generations will have to be studied to completely determine the inheritance pattern of these characters.

Effect of Potassium Levels on Susceptibility of Alfalfa to Fusarium oxysporum medicaginis (Fusarium wilt)

An experiment was conducted in the greenhouse to study the effects of Fusarium oxysporum medicaginis on 6 strains and varieties of alfalfa grown in a sand medium at high and low K levels. At the low K level, plant dry weight and the % of K in plant tops were reduced; however, disease development did not differ at the two levels of K. The alfalfa strains and varieties differed significantly in susceptibility. Twenty percent of the plants of mass selection A (developed in North Carolina) were killed by the pathogen compared with 53% of DuPuits. Although F. oxysporum medicaginis is considered to be a "southern" pathogen it has been isolated twice from diseased plants in Pennsylvania.

Isolations from Diseased Alfalfa

Numerous isolations were made from diseased alfalfa plants in central and southern Pennsylvania. Primary pathogens were Colletotrichum sp., Corynebacterium insidiosum, and Fusarium oxysporum medicaginis. Two other organisms commonly isolated, F. solani and Rhizoctonia solani, were not pathogenic to two-month old alfalfa plants in trials in the greenhouse.

Red Clover

Persistence of Selections of Red Clover with a Low Incidence of Internal Breakdown (IB)

Field plots were established in May 1964 to determine if IB "resistant" selections would persist longer than recommended commercial varieties. Approximately 2 g of seed were broadcast in each 5' x 5' plot. Most entries were replicated six times. Entries included 11 polycross selections for low incidence of IB, 3 persistent selections developed in a previous study (1963 Annual Report, p. 4), 4 foreign introductions, Pennscott, Kenland and Lakeland.

Due to a very dry summer good stands were not obtained in all plots. Ground cover notes and plant counts were made so that the poor establishment could be considered when taking subsequent notes.

Internal Breakdown (IB) of Red Clover

In 1963, F_4 plants from lines selected for low incidence of IB were polycrossed using honeybees in a greenhouse compartment. The seeds were planted in 4" pots in 1964. Pennscott and selections for high IB incidence were also planted. After 6 months the following data were obtained.

	<u>No. plants examined</u>	<u>Avg. root diam. (mm)</u>	<u>% of plants with IB</u>
Polycross progeny— IB resistant	372	9.0	9
Variety — Pennscott	153	9.7	42
IB susceptible selection	77	7.6	80

Some of our previous work indicated that IB was associated with aging (or senescence) of plant tissue. There are reports in the literature that radiation damage in mice appeared to be similar to aging. Therefore, seed and seedlings of red clover were subjected to gamma and thermal neutron (T.N.) radiation to determine their effect on the incidence of IB.

Irradiation of Pennscott red clover seed with gamma rays had little effect on growth of seedlings or incidence of IB. The higher rates of thermal neutrons (T.N.) reduced emergence of seedlings and caused leaf distortion at all dose rates. The incidence of IB appeared to be increased at the higher levels of T.N. Irradiation of red clover seedlings with T.N. resulted in yellowing of leaves, misshapen leaves and dwarfing. The incidence of IB in Pennscott (susceptible to IB) was increased and the root diameters decreased at the higher dose rates. Thermal neutrons appeared not to increase IB incidence in 3 resistant selections.

Over the past several years many greenhouse tests have been conducted with the aim of determining the cause of IB. Variables included: soil mixes of various physical structure and fertility, minor elements, various major-element-ratios, seed of various ages, varieties of red clover, soil moisture levels, inoculations with fungi, bacteria, and viruses, increasing CO_2 level around the crown, and increasing sugar content in the crown. In most of the tests, incidence of IB in the variety Pennscott was not affected directly by the treatment. However, where a certain treatment favored growth of the plant, there appeared to be more IB. To elucidate this point data from all previous experiments were pooled on the basis of root diameter and age of plant and percentage of IB. Plants with the same taproot diameter, regardless of chronological age (4 mo. to 9 mo.), had approximately the same incidence of IB. Field plants ranging in age from 4 to 30 mo. with the same diameter also had approximately the same percent of IB.

Effect of Various Environmental Conditions on the Incidence of Internal Breakdown (IB) in Red Clover

Several experiments were conducted to determine the effects of daylength, temperature, soil moisture, frequency of clipping, and plant competition—as they affect growth and plant maturation—on the incidence of IB. In experiment 1, variables (in all possible combinations) included high and low temperatures, frequent clipping and clipping of flower stalks only (when in full blossom), and 1 and 3 plants per 4-inch pot. In experiment 2, daylength was varied instead of temperature. Soil moisture (frequency of watering) was varied in other tests.

Treatments appeared to have no direct effect on the incidence of IB. Highest % IB occurred in treatments most favorable for plant growth, e.g., low temperature, short day, lenient clipping, and 1 plant per pot. Taproot diameter was directly correlated with incidence of IB.

Pathogenicity of Fusarium spp. Isolates from the Northeast

Cultures of Fusarium spp. sent in by researchers in the NE-45 Project were tested for pathogenicity by the following methods:

- (1) Emergence in various media infested with each isolate of Fusarium in petri dishes.
- (2) Placing infested soil around clipped roots of 10-11 week-old plants in steamed soil.
- (3) Same as number 2 except autoclaved river sand was used instead of soil and plants were only 4 weeks old.

All isolates reduced emergence of red clover and alfalfa in one or more media. In the inoculation of older alfalfa plants two isolates of F. oxysporum medicaginis were pathogenic while two isolates of F. solani were not. Seven isolates from red clover, which included F. solani, F. moniliforme, F. oxysporum and F. roseum, were only slightly pathogenic to plants of red clover. In the inoculation of one-month-old seedlings of red clover in 3-inch pots of sand, the isolates from red clover were not pathogenic or only slightly so.

Bromegrass

Selections with Leaf Disease Resistance

(In cooperation with G. M. Dunn, University of New Hampshire)

Based on results from the Pasture Laboratory and from New Hampshire, 2 synthetics have been formulated. One Synthetic D which will be constituted from 6 clones has apparent resistance to Pyrenophora bromi and Stagonospora bromi. Synthetic E has resistance to these 2 diseases and some resistance to Rhynchosporium secalis and will be based on 6 clones which have been progeny tested by use of polycross. Small quantities of Syn 1 seed were produced in the greenhouse and will be used to establish plants in isolation blocks for production of Syn 2 seed. Seed of Syn 1 and Syn 2 will be available for forage testing in 1967.

Orchardgrass

Breeding Improved Orchardgrass

(In cooperation with J. L. Starling, The Pennsylvania State University)

Two polycross progeny tests of late-maturity orchardgrass were established in 1963, one to evaluate hay yield and the other to evaluate recovery and stand after frequent clipping. The average hay yield for 2 cuts was 2.21 TDM/acre in 1964 which was a very dry year. Pennlate yielded 2.05 TDM/acre which was 0.38 TDM/acre less than the average polycross yield for the 4 parental clones of Pennlate. This significant difference may have been due to the lower seed quality of Pennlate. Seed from a polycross nursery, which is slightly earlier than Pennlate but included 2 Pennlate clones, MIV-5 and MIV-17, was harvested and will be used in a progeny test in 1965.

Nonheading Orchardgrass

(In cooperation with H. M. Yegian, University of Massachusetts and G. M. Wood, University of Vermont)

No carry-over effect on flowering response from the parental clone to the tiller was demonstrated, as the response was unrelated to previous flowering response of the parental clone. Two clones flowered in the greenhouse only after pretreatment of short daylength at 50° F until January 1 or February 1. Four other clones flowered after shorter cold treatment; all 6 flowered

following overwintering outdoors. The variable flowering response which some of these and other clones have shown in the field over a period of 6 years may have been in response to the fall or spring temperatures. None of the clones is truly nonheading at University Park.

Syn 1 seed of 3 synthetics produced at Prosser, Wash., was used in replicated plantings in Massachusetts, Pennsylvania, and Vermont to observe physiological and agronomic characteristics at different locations.

Male-Sterile Orchardgrass

Progenies from several crosses were examined during anthesis. Data from 2 crosses suggested that the male-sterile condition is recessive to male-fertile and that one male-fertile allele is sufficient to produce the dominant phenotype. Plants were selected and further crosses were made to determine the genetic basis for this character.

Ryegrass

Interspecific Hybridization and Species Relationships

Fisher's discriminant analysis, which is a multivariate procedure, of 7 to 9 quantitative characters of several species indicated that the species were generally distinct. Several P.I. introductions appeared contaminated. Choice of characters may contribute to the disparity between results obtained by different workers. Some interspecific F_1 and F_2 hybrids could not be distinguished statistically from the maternal parental accessions with the characters used. Discriminant analysis provided some insight into species relationships not apparent from univariate analyses.

Ryegrass-Fescue Intergeneric Hybrids

Breeding and Evaluation of Fertility and Persistence

Examination of trispecies intergeneric hybrid derivatives from backcrossing to tall fescue confirmed stability of the hexaploid ($2n = 42$) chromosome number. Heritability of seed yield by parent-offspring regression was 25% based on performance of polycross progeny test of 33 clones. The mean seed yield and mean seed set for 15 clones which were considered intermediate between the parent species did not differ from the corresponding means for 18 clones which resembled more closely the tall fescue parent, suggesting that the BC_1 generation may suffice in raising the fertility level of these trispecific derivatives. The forage yield test was inconclusive due to prolonged summer drought. A grazing trial at Lexington, Kentucky, with 50

clones in a replicated cafeteria-style nursery showed that 5 ranked numerically better than but were not statistically different from Ky 31 tall fescue, possibly because of susceptibility to netblotch, Helminthosporium dictyoides. A total of 94 topcrosses was established to evaluate and select for field resistance to netblotch, and several 4-clone synthetics were formulated for further evaluation.

Studies were continued on the morphological and cytogenetic effects of 2 levels of thermal neutrons on 8 clones of $2n = 28$ chromosome intergeneric hybrid derivatives. Generally, the high level of 60 min radiation weakened the tillers and reduced the growth rate more than did the 30 min radiation but the effects were less apparent at the end of the growing season. Cytogenetical observations of chromosome associations during meiosis indicated little difference between the 2 treatments. Results from open pollination and reciprocal single crosses of 16 intergeneric $2n = 28$ chromosome clones showed most of them to be sterile.

Cytogenetics of Ryegrass-Fescue Material from Kentucky

Chromosomes were counted for 83 plants which were amphiploids or other derivatives of annual ryegrass X tall fescue hybrids, to aid in selection of genotypes for further breeding work. At present no morphological traits appear to be associated with certain chromosome numbers.

BIOCHEMISTRY, PHYSIOLOGY AND SOILS

Carbohydrate Studies on Forages

Studies on hemicelluloses of forage plants are being continued (1963 Annual Report, p. 9). A quantitative study of total hemicellulose was completed in 100 samples of forages and of the feces of animals fed the forages. The three components of the cell wall, hemicellulose, cellulose, and lignin were compared with one another quantitatively and with some digestion coefficients. The results of the analysis of the forages are given in Table 1. The hemicelluloses were lower in alfalfa and legume silage (alfalfa and red clover) than in the grasses, both as percentage and in relation to the cellulose content. On the other hand, the legumes were higher in lignin. These differences may be considered characteristic of the cell wall composition of the two plant families.

Some digestion coefficients are given in Table 2. The differences in digestibility of dry matter may not be characteristic of the species in all cases but the differences between the digestibility of hemicellulose and that of cellulose are significant and indicate that the former is less digestible.

Table 1. Mean composition of forages, in percent of dry matter and some ratios between hemicellulose and cellulose.

Forage	No.	Hemicellulose, %	Cellulose %	Lignin %	Ratio of hemicellulose to cellulose
Alfalfa	17	12.8	27.0	9.0	.47
Legume silage	9	12.7	31.9	11.4	.41
Orchardgrass	23	17.6	29.0	6.1	.61
Bromegrass	16	18.2	29.6	5.9	.61
Timothy	13	20.0	31.2	6.6	.64
Reed canarygrass	8	19.0	30.1	6.4	.63
Kentucky bluegrass	5	20.5	27.5	4.5	.74
Ky 31 fescue	9	19.6	26.6	4.3	.74

Table 2. Mean digestion coefficients of forages by species.

Forage	Dry matter	Hemicellulose	Cellulose
Alfalfa	62.5	59.6	61.5
Legume silage	59.2	58.7	66.1
Orchardgrass	68.0	72.1	77.0
Bromegrass	67.7	71.6	74.7
Timothy	63.4	66.5	69.6
Reed canarygrass	60.2	61.3	64.9
Kentucky bluegrass	71.8	75.5	80.1
Ky 31 fescue	63.4	--	--

Some correlations were noted in the data. Digestibilities of dry matter and of the carbohydrates were negatively correlated with the lignin content and with few exceptions all coefficients were highly significant. The correlation between lignin and the digestion coefficient of hemicellulose was greater than that between lignin and the digestion coefficient of cellulose in alfalfa. This indicates a closer union between lignin and hemicellulose than between lignin and cellulose. The ratio between hemicellulose and cellulose is positively correlated with digestibility in all cases except timothy and with few exceptions all the coefficients are highly significant. This last is not an obvious relationship, that when a higher proportion of a less digestible constituent (hemicellulose) is present, the cell wall material is more digestible. This ratio is also negatively correlated with the percentage of lignin. These relationships might be explained on the basis of the existence of a lignin-hemicellulose complex. It may also be postulated that, in alfalfa, cellulose is digested independently of hemicellulose and is less dependent on lignification. These studies are to be continued on forages of known voluntary intake.

Climate at State College, Pa.

Meteorological factors were measured on a bluegrass sod area 100 feet northeast of the main laboratory building and attempts were made to interpret relationships of these observations. Air, dewpoint, and soil temperatures were measured as were precipitation, soil moisture, air movement, solar radiation and cloud cover. Evaporation was measured daily at two heights above the sod.

For the year the mean air temperature was 0.8 degree above normal (30-year mean, 1931-1960, U.S.W.B.). Mean monthly air temperatures for February and October were 3.3 and 2.1 degrees below normal respectively while for March, May, July and November respective temperatures were 2.2, 4.4, 2.9 and 4.4 degrees above normal. Comparisons of monthly and yearly averages of daily temperatures 3 inches and 60 inches above the sod indicate that the yearly average of daily mean temperatures without snow, March-December inclusive, is 0.6 lower at the 60-inch height. Monthly averages indicate that daily mean temperatures were 0.3 to 1.3 degrees lower at 60 inches in March and June respectively. During the fall the temperatures of the two heights were alike except that under snow the daily means at 3 inches were higher. Averages of the daily ranges between maxima and minima at the two heights indicate that under snow cover the range at 3 inches is 4 or 5 degrees less than at 60 inches. During the spring the daily temperature range increased more nearer the sod and was two degrees greater than at 60 inches in March, four degrees greater in April, and five to eight degrees greater during the summer and fall. The range then decreased to 3 degrees in November and to 0.9 in December.

Monthly averages of mean daily dewpoint temperatures 60 inches above the sod indicate that these increased from 18° in February to 60° in July and then decreased to 45° in September, and to 17° in December. Dewpoints 3 inches above the sod increased from 45° for May to 62° in July and then

decreased to 11° in November. Monthly averages of daily ranges of dewpoints at the 60-inch height were largest, 14° , in March and least in July, 8° . In the fall daily ranges increased again and reached 13° in December. At the 3-inch height a similar pattern of ranges occurred with the largest, 14° in May, the smallest 10° in July, and followed by an increase to 12° in September.

Soil temperatures at five depths, 2, 4, 8, 12 and 16 inches in the sod, were measured and recorded bihourly. Monthly and yearly averages of daily mean temperatures indicate that irrespective of depth average temperatures for the year are practically the same, 55.5° at two inches and 54.1° at 16 inches. Monthly averages of mean daily temperatures vary with season. For February the coolest month, mean temperatures were 31, 32, 33, 33, and 35° respectively at 2-, 4-, 8-, 12-, and 16-inch depths while in July the month with warmest soil temperatures they were 79, 77, 75, 73 and 72° . Yearly averages of daily ranges from maximum to minimum temperatures at the 2-, 4-, 8-, 12- and 16-inch depths are 11, 8, 4, 2, and 1° respectively. Monthly averages of the daily ranges were least in February being 1.8 and 0.8° at 2- and 16-inch depths and largest in July being 18, 14, 6, 2, and 1° respectively 2, 4, 8, 12 and 16 inches deep. Minimum temperature at the 2-inch depth occurred at sunrise and daily maxima between noon and 2 p.m. At 16 inches depth, maxima occurred near midnight and minima near noon. At other depths the times when maxima and minima occurred were intermediate.

Precipitation in 1964 was 30.27 inches which is 8.43 inches less than normal (30-year mean 1931-1960, U.S.W.B.) for this location. Times with below normal precipitation were distributed within eight months, one in early spring, three in the summer and four during fall and early winter. Near normal precipitation occurred in January, February and August while in April it was 2.39 inches above normal. Not only did fewer rainy days occur but the amounts of precipitation received were low.

The percent available moisture was determined at six depths within the bluegrass sod. While soil moisture in early May was near field capacity at all depths, 2, 4, 8, 12, 16 and 20 inches, it then decreased rapidly and by June 5 was low at the 12-inch depth. Moisture remained continuously low and near wilting at all depths until August when rainfall slightly increased the moisture even 20 inches deep. Limited precipitation thereafter resulted in low soil moistures at all depths in mid-November.

Evaporation was measured daily from mid-May through September with black and white atmometer bulbs placed 3 and 60 inches above the bluegrass sod. Nine biweekly summaries, from May 16 to September 30, indicate that most evaporation occurred during the period May 16-31 when humidity was lowest, and the daily rates of air movement and daily radiation intensities were greatest. At both heights more evaporation occurred from the black bulb and the least from the white bulb nearest the plants, and even when radiation intensity was low. Averages of all observations were used to compare effects of height and these indicate that evaporation from the black bulb at the 60-inch height was 1.25 times greater than that at 3 inches while evaporation from the white bulb at 3 inches was 1.42 times greater than at 60 inches.

Comparisons of relative evaporation from black and white bulbs at 3 inches and 60 inches indicate that near the sod the black bulb lost 1.39 times as much water as that from the white while at 60 inches the black lost 1.22 times as that from the white.

The observations taken in 1964 exemplify interactions of radiant energy absorbed and the resultant heating of moist surfaces and also that lower ambient humidities and air movement increased rates of evaporation. Interactions of these factors on water losses must be considered when evaporation measurements are evaluated and interpreted.

Biological Measure of Reserves, Effects of Temperature
and Duration of Growth in Darkness on Measures
Expressed as "Milligrams per Tiller"

Plant growth is dynamic and is maintained by radiant energy from light fixed during photosynthesis. The energy not utilized in forming new stems, roots and other plant parts accumulates as carbohydrates and is available for use during subsequent extension and development. Because chemical and biological measures of this accumulated energy are closely correlated and because chemical methods require greater skill and special equipment, efforts were continued to improve biologic procedures and to make them more adaptable at various locations.

In these experiments, the rate and amount of growth in darkness and the variability in duration of growth were measured at three ambient temperatures. One clone of orchardgrass was grown in the greenhouse and given different clipping treatments to provide plants with five levels of reserves. Plants from these treatments were clipped and moved into darkness to recover at temperatures of 65°, 80° and 95° for various periods of time relative to the estimated levels of reserves within them. The rates of leaf extension occurring in darkness were also measured. Comparisons were made of total top growth made by entire pots and also when growth is based on the number of tillers from which growth occurred. Relative growth made by tissue with five levels of accumulated energy, indicated similar relative levels of reserves when expressed as "milligrams per pot" and as "milligrams per tiller." The relative growth in darkness is generally similar at the three temperatures but at 95° lower levels of reserves were consistently indicated. At 80° and 65° similar levels of reserves were indicated. For valid comparisons recoveries in darkness of plants taken from field plots or from greenhouse benches, growth should be near room temperature and high temperatures should be particularly avoided.

Measures of leaves grown in darkness indicated that the final length was least at 95° and about the same at 80° and 65°. The rates of growth, millimeters per day, varied with levels of reserves and temperatures. Growth at 80° was consistently faster at all levels of reserves while growth at 95° and at 65° was slower but similar to each other.

Rates of leaf extension during the first, second and third week in darkness at 95°, 80°, and 65° varied appreciably. At 80° growth rate was most rapid and, with plants having high reserves, it was constant for two weeks, but with low-reserve plants it decreased after one week. On plants with high reserves at 95° growth remained rapid for 10 days while with low reserves

it was for only 2 or 3 days. At 65° growth was slowest and continued for 10 and 21 days on plants with low and high reserves respectively. It was evident that when elongation was 4 mm or less in a day, reserves were becoming low and top growth should be harvested and the dark growth period terminated.

In addition to measures of levels of reserves as milligrams per tiller at 65°, 80° and 95° F the percentage of reserves recovered by growth in darkness was also measured. Comparisons of different levels of reserves as "percent recovered" with "milligrams per tiller" indicate that 1% of reserves is generally equivalent to 2 or 3 mg/tiller. When reserves are low, 4 or more mg/tiller are equivalent to 1% of reserves recovered. At 95°, the percent recovered was lowest and was about half that at 65° and 80° which were similar to one another.

In summary, it is evident that for biological measures of reserves, dark temperatures between 70 and 80° are satisfactory. When the daily extension of orchardgrass is 5 mm or less a final harvest of top growth should be made and the stubble taken from the soil, roots and extraneous tissue removed, and then cleaned and dried. From dry weights of etiolated leaf growth, the number of tillers from which it was produced, and also the dry weight of the spent stubble, measures of reserves may be expressed as mg/tiller or as percent of reserves recovered. Chemical analyses of similar plants will allow evaluations of both, the chemical and biological measures.

Phosphorus Fertilization of Grasses and Legumes

Phosphorus withdrawal and physiological analysis of yield of ladino clover—
Effects of P nutrition on the physiological analysis of yield of ladino clover grown in 3 nutrient solution culture experiments indicated that Net Assimilation Rate (NAR) was severely reduced when leaf P contents were less than 0.2 percent. NAR was highest at average temperatures above 70°F and light energy values over 500 gm-cal/cm²/day. As plants matured NAR was little affected but the Relative Leaf Growth Rate (RLGR) decreased. Light and temperature influenced NAR more than did P nutrition, whereas the latter had relatively greater effects on RLGR than the greenhouse environmental conditions. It is suggested that the higher P requirement for RLGR than for NAR may be because RLGR involves cell division and meristematic activity, while photosynthesis is carried on mainly in mature cells. There was a high correlation between leaf weight and leaf area suggesting that, in studies involving the physiological analysis of yield, either measure would be satisfactory.

Phosphorus withdrawal and mineral element distribution in ladino clover—
The effect of P nutrition on the distribution within ladino clover of 11 major and trace nutrient elements determined by emission spectrophotometry emphasized the importance of physiologic age (maturity) on leaf mineral composition. It was found that immature leaves had the highest P and Zn contents and older, more mature leaves the lowest amount of these two elements. More Ca, Mg, B, Mn, Fe, and Al were present in maturer leaves

than in those that were immature or young. Potassium and Cu were relatively unaffected by leaf age. Roots were high in P and could function as a reservoir for this element provided the plants had been grown in a high P supply medium. Calcium and Mn were higher, and Zn lower, in roots that also had high P contents. The percentage of P, Ca, B, and Fe were generally increased by P fertilization and K and Al decreased, while Mg, Mn, Cu, Zn, and Na were relatively unaffected by P treatment.

Response to phosphorus when other elements are not limiting: effect of sand amendments—In a species, soil texture, and P fertilization trial the mixing of inert coarse or fine white sand in soil at various P levels depressed plant growth except at the zero P treatment. Both ladino clover and timothy responded strongly to P fertilization. It was found that plant root activity, as determined by the amount of methylene blue dye adsorbed per unit weight of root, is apparently influenced by root size, or age. This may represent a changing root surface area/root weight relationship, or changes in affinity of the root for dye adsorption. For critical determinations of root activity, the methylene blue procedure employed in the present study may require calibration with plant species, age, and root size.

Potassium Fertilization of Alfalfa and Orchardgrass

Competition for potassium by alfalfa and orchardgrass when seeded in alternate and mixed rows—Forage yields were low due to droughty conditions in the first full harvest year of an alternate- and mixed-row seeding field experiment evaluating alfalfa and orchardgrass competition for K. Response to initial K treatments was slight. Percent alfalfa increased significantly from the 1st to the 3d cutting, attributed to its water-foraging ability. Limited plant analyses showed orchardgrass to be much higher in percent K than alfalfa. The unfertilized alternate-row treatment plants contained a higher percent K than those in the unfertilized mixed-row, which may indicate an advantage of seeding forage species with the alternate-row seeding method.

Soil Properties Affecting Growth and Disease Susceptibility

Red clover response to soil moisture stress—In an experiment to investigate effects of soil moisture stress on growth and disease susceptibility of red clover using several soil moisture levels and regimes, the optimum (21% soil moisture) watering level produced the most top dry matter with the dry (14% soil moisture) level producing unexpectedly well. Wet (31-35% soil moisture) treatments were detrimental, tentatively attributed to ineffective nodulation and/or excessive denitrification, resulting in N deficiency in the plants. Prior and present soil moisture regimes affected dry matter production, number of vegetative and new axillary branches per plant, and flower and flowering stem numbers. Clover regrowth was influenced more by the present soil moisture regime than it was by former plant size, as estimated by the 2d harvest/1st harvest top growth ratio. Regrowth after the first cutting was better under optimum soil moisture regardless of previous soil moisture status. Incidence of Internal Breakdown of red clover was little affected by soil moisture treatments.

REPORTS OF R. AND M. COOPERATIVE RESEARCH

Title: PROJECT NE-9 - THE INTRODUCTION, TESTING, MULTIPLICATION, AND PRESERVATION OF POTENTIALLY VALUABLE PLANTS FOR CROP IMPROVEMENT AND INDUSTRIAL USE

Leader: H. M. Munger, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs and New Haven), Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Cornell and Geneva), Pennsylvania, Rhode Island, Vermont, West Virginia, N.C.R.B., C.S.R.S., S.C.S., Eastern Util. Res. Dev. Div., A.R.S., U.S.D.A.

The complete report, in respect to forage crops, listed several accessions of legumes and grasses which were noted as promising in the Geneva nursery. The alfalfa selections totaled 54 and included 5 of the spreading type, some of which spread 18 inches without irrigation in a very dry year. The most promising of many red clover selections were from New Hampshire, the Netherlands, and Switzerland. Eight white clovers, 14 ladino clovers, and 26 intermediates were mentioned as superior. A ladino with high virus tolerance was from Australia, and another from Spain. Only 1 alsike, from Sweden, showed virus tolerance. Three outstanding zigzag clovers came from New Zealand. A type from Germany and Yugoslavia, vigorous and more upright than zigzag, was identified as T. medium but may be T. melilotus instead. Of 19 promising birdsfoot trefoils, some were tolerant to Phomopsis loti; one from Denmark was especially free from Stemphylium loti.

Of the grasses, promising selections included 5 tall oatgrass, one brome-grass, and 6 orchardgrass, one introduction of which from Poland was the most vigorous but was susceptible to both leafspot and rust. There were 12 promising introductions of tall fescue, a most vigorous one from South Africa, 11 of perennial ryegrass, 2 of reed canarygrass, and 9 of timothy. The full report gives more detailed description and the P.I. numbers.

The Plant Introduction Station at Geneva has new office and laboratory space for the pathologist. A project recently completed was for brown leafspot resistance in brome-grass introductions. Current projects for testing leaf and stem rust resistance in timothy and in tall oatgrass and for screening alfalfa introductions for black stem resistance are in progress.

Title: PROJECT NE-13 - STUDIES OF THE PHYSICAL PROPERTIES, BEHAVIOR, AND FORMS OF FORAGE AS RELATED TO ENGINEERING APPLICATION

Leader: W. L. Kjelgaard, Chairman, Regional Technical Committee

Cooperators: The twelve Agricultural Experiment Stations of the Northeast Region, A.E.R.D.-A.R.S., and C.S.R.S.-U.S.D.A.

Studies were continued to determine why steaming a forage plant for two minutes resulted in a more rapid release of moisture. Photomicrographs revealed that leaf and stem stomata remained open for a longer period and that steaming at least partially removed the wax coating on the leaves and stems. Leaves and petiole were separated from the stem and then dried separately. Results show that leaves and petiole play an important role in the removal of moisture from the stem.

A physiological response in alfalfa plants when they are treated with sodium azide results in a faster drying rate than for untreated plants during the early stages of drying. The sodium azide treatment fixed the stomata on the alfalfa plant open, provided that the stomata were open at the time of treatment.

Studies of the sorption characteristics of alfalfa hay revealed that drying temperature, minimum moisture content, environment, and season had a significant effect on the sorption isotherm. Other variables, such as air flow rate, physical configuration, sample size and density, produced only slight effect on sorption properties.

The variables of density, initial moisture content, and pre-drying spontaneous heating time were analyzed with respect to the drying characteristics of baled hay. The variable of density had the greatest effect on drying time. Spontaneous heating effects on the drying time were inconsistent with one and five hour periods showing maximum response.

Pre-baling treatment of hay with antibiotics and ultraviolet radiation to reduce spontaneous heating levels were studied. Streptomycin and Streptomycin-Rose Bengal treatments reflected the largest temperature reduction. Low level ultraviolet exposure displayed reasonable temperature reduction in hay samples; however, excessive time was required to administer the treatment.

The relationship between measured values of an electrical characteristic "Q" and the moisture content of alfalfa samples over a wide range of moisture contents is a smooth curve with good sensitivity. The most effective frequency is 20 megacycles.

Studies of physical properties of haylage were concentrated on quantitative evaluation of lateral shear strength and tensile strength. Data under analysis involve the variables of forage type, density, and moisture content. Apparatus and technique for determining the tension properties of haylage were developed.

A series of tests were run involving proposed and adopted standard procedures for hay wafer measurements. The results developed from these tests are being used to establish workable and meaningful standard technology. The drying performance and air flow resistance properties of several sizes of hay pellets were determined. The presence of fine material interspersed with whole pellet units greatly increased air flow resistance. In comparison to chopped or baled form, hay pellet drying with heated air is difficult.

Experiments on the energy required for impact cutting of alfalfa showed that for plants above 45% moisture the lowest cutting energy values were associated with knife velocities above 7400 ft. per min. The highest cutting energy was required at a knife velocity of 4800 ft. per min. and 75 degree knife angle. Minimum compression force perpendicular to the axis of alfalfa stems occurred at 40% moisture content.

The temperature of hay over a range of 70 to 210° F at the time of compression into hay wafers was evaluated in terms of wafer density, pressure requirements and durability. Higher temperatures produced a consistent decrease in pressure requirements, but 130° F marked the most favorable density and durability properties.

USEFULNESS OF FINDINGS:

The measurement of the electrical characteristic "Q" of alfalfa by an electric circuit can be used to determine the moisture content of the forage.

The fact that the drying rate of alfalfa can be influenced by a physiological response to a chemical, in this case, sodium azide, opens a new area of investigation.

Data on lateral shear strengths and tensile strengths of haylage supplemented with vertical shear strengths previously evaluated, provide a basis for understanding the behavior, and design requirements of units for handling haylage.

Energy requirements for impact cutting and the interacting effects of knife angle, moisture content and speed on cutting energy will provide information for designing forage cutting mechanisms.

Hay wafer properties and their measurement technology developed through experimentation will be useful to other research workers and industry.

The air flow resistance and drying properties of hay pellets provides information for application to design problems.

Title: PROJECT NEM-22 - FACILITATING THE MARKETING OF SEEDS THROUGH IMPROVED TESTING PROCEDURES

Leader: Leroy W. Nittler, Chairman, Regional Technical Committee

Cooperators: Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Geneva and Ithaca), Pennsylvania, and Rhode Island Agricultural Experiment Stations, F.C.R.B., ARS, USDA - C. S. Garrison, V.O.R.B., S.E.S.D., ARS, USDA, and B.S.B., A.M.S., USDA

In Maryland plants of 5 varieties of red clover were grown in growth chambers and records were kept on time of bloom, flower color, plant height, and leaf markings to determine whether varieties differ in these respects. Fourteen seed lots were used to ascertain whether seed lots within varieties are different.

In New York chemical treatments were used on seedlings of varieties of several forage crop species to induce differences that could be used in testing seed lots for varietal purity. Maleic Hydrazide proved to be useful in testing alfalfa seed for varietal purity, TEPP was useful in testing red clover varieties and 2-chloro-6- (trichloromethyl) pyridine was useful in testing timothy varieties.

N-dimethylaminosuccinamic acid, sold under the trade name of B-Nine, was useful in distinguishing the late maturing type of birdsfoot trefoil from the early type. Treated plants of the late maturing variety, Empire tended to be decumbent or semi-decumbent, whereas plants of the early maturing varieties tended to be upright. Twenty-eight samples of birdsfoot trefoil seed were tested for seed companies with the aid of B-Nine. The chemical increased the precision with which determinations could be made and also made it possible to make determinations within 4 weeks as compared to 6 weeks usually required for untreated plants. Since the results of treating greenhouse grown birdsfoot trefoil seedlings with B-Nine varied from one time of the year to another, investigations were conducted in growth chambers to isolate environmental conditions that influence the reaction of seedlings to this chemical. Daylength, light intensity, light quality, and night temperatures were all found to influence the results.

Environmental conditions for inducing varietal differences in timothy and perennial ryegrass were studied. Warm light periods and cold dark periods favored development of varietal differences in perennial ryegrass. Exposure to cold temperatures or short photoperiods before being transferred to conditions favorable for production of heads favored varietal differences of timothy in time of blooming.

In Pennsylvania trials were conducted to measure color differences of alfalfa varieties quantitatively using a color coder and a spectrophotometer. Both flower color and the color of small seedlings were studied. Greenhouse, growth chamber, and field grown plants were used. The effect of these growing conditions as well as the effect of soil pH and fertility in the field were studied. Significant varietal differences were found both in flower color and in the color of seedling plants.

To ascertain if alfalfa varieties grown in different years and geographic locations differ in content of 11 essential elements, 40 seed lots each of 14 different alfalfa varieties and 6 seed lots of 2 different varieties were analyzed on a recording spectroscope.

Using paper and thin layer chromatography, a series of trials were carried out to study varietal differences in 3 varieties of crownvetch, 4 varieties of smooth brome grass, and 4 varieties of orchardgrass. Phospholipids, free amino acids, and leaf phenols were studied. Varietal differences were noted.

Crownvetch contains a brownish colored leachable substance beneath the outer seed coat. To ascertain if there were varietal differences in content of this substance, 10 seed lots each of 3 varieties were leached under standard conditions and transmission read at 375 m μ on the spectrophotometer. Significant varietal differences in concentration of the leachate were noted.

Title: PROJECT NE-24 - NUTRITIVE EVALUATION OF FORAGES

Leader: R. W. Hemken, Chairman, Regional Technical Committee

Cooperators: The 12 Northeastern States, the U. S. Regional Pasture Research Laboratory, Dairy Cattle Research Branch, ARS, and Cooperative State Research Service, USDA.

The objectives of this regional project are: (1) to evaluate forages of various species and varieties grown under known conditions and harvested at specific dates and stages of maturity by determining the digestibility of energy and protein and the daily consumption rate; in fewer instances, forages will be evaluated in terms of animal production responses and energy balances, and (2) to determine the fundamental conditions controlling the amount of forages ingested by ruminants and to develop methods for measuring and predicting the daily forage consumption rate.

Various factors influencing the nutritive value of forages as measured by daily rate of consumption and digestibility were studied during the past year by many of the stations. Factors studied were: (1) nitrogen fertilization (Delaware, Pennsylvania, Rhode Island, and West Virginia); (2) forage varieties within a species (Delaware, Maryland, New Jersey, New York, and Dairy Cattle Research Branch, A.R.S.); (3) cutting data and growth stage (Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Dairy Cattle Research Branch, A.R.S.); (4) phosphorus fertilization (Maine and West Virginia); (5) potassium fertilization (West Virginia); (6) effect of time of first cutting on aftermath growth (Maine and Vermont); (7) physical form of forage (New York); and (8) source of nitrogen (West Virginia).

Several species of animals were used in predicting the nutritive value of forages. Data comparing sheep and rabbits (Delaware) indicate that while rabbits can be used to predict digestibility of forages, rabbits were not

satisfactory for intake measurements. When comparing cows with sheep (Massachusetts), it was found that cows had a higher total intake rate with a higher level of corn silage to reed canary hay than did sheep receiving these same rations. Additional data comparing cattle and sheep (New Hampshire and New York) were obtained. One study (New Hampshire) indicated that sheep gave higher metabolizable energy and net energy values than did cattle. Net energy, as measured by stored energy with the comparative slaughter technique, decreased slightly with advancing maturity of forages (New Jersey).

Further data (Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Dairy Cattle Research Branch, A.R.S.) emphasized the importance of early harvesting to obtain the greatest nutritive value. However, studies with orchardgrass and brome grass (Delaware, Maryland, and Pennsylvania) indicate that the decline in nutritive value of grasses may be more rapid than the decline in the nutritive value of legumes. The decline in nutritive value of aftermath harvests (Maryland and New York) was not as great as indicated by data previously reported for first cuttings.

Rumen fermentation patterns as affected by ratios of corn silage and hay (Massachusetts) and forage intake (Maine) were studied to check possible relationships between VFA levels and the nutritive value of various forages. Intake was correlated with n-valeric acid (Massachusetts). The effect of undigestible fiber (polypropylene) introduced into the rumen had a marked effect in reducing voluntary intake of chopped forages (New Jersey).

Progress was made in the development and use of chemical methods for nutritive evaluation of forages. A study (U. S. Regional Pasture Research Laboratory) of the hemicellulose content of forages indicated that lignin may be more closely associated with hemicellulose than with cellulose in alfalfa, and that some of the hemicellulose from the more digestible fraction of legume silage may be lost during silage fermentation. Although hemicellulose had a lower digestibility than cellulose, there was a positive correlation, in most species and in the total population, between the hemicellulose:cellulose ratio and the digestion coefficient of the cellulose or of the total dry matter. The further development and use of cell wall constituents was studied by several stations (New Jersey, West Virginia, and Dairy Cattle Research Branch, A.R.S.). This technique is being used to study the effect of fertilization levels (West Virginia) and forage varieties variation (New Jersey). Collaborative work (Dairy Cattle Research Branch, A.R.S.) with the AOAC has been initiated on acid-detergent fiber and lignin for the purpose of establishing these as official methods.

Fertilization studies with nitrogen and nitrogen sources (West Virginia) showed little effect of treatment on ad lib. intake and digestible dry matter with first cutting hays. Pennsylvania reported that voluntary consumption of dry matter was lowest of all for the second harvests which had been grown with nitrogen at the levels of 50 and 100 lbs. per acre.

Data accumulated from all stations of the region on the relationships of cutting date and maturity to the yield and nutritive value of forages will serve as the basis for recommended management practices. Prediction equations and in vitro techniques are being developed to predict nutritive value.

Plant geneticists are being aided in the development of new forage varieties by giving them methods by which they can predict the nutritive value of the forages at an early stage of development.

The work on the effects of fertilizer treatments with minerals upon the nutritive value of forages will provide much needed information for sound recommendations on the important phase of the management of forages and their utilization. Previous results have shown the effects of nitrogen fertilization of grasses upon yield and nutritive value, and present emphasis is now being placed on mineral nutrients and possible interactions.

Title: PROJECT NE-28 - BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST

Leader: R. W. Cleveland, Chairman, Regional Technical Committee

Cooperators: Connecticut, Maryland, New Hampshire, New York (Cornell), Pennsylvania, West Virginia, the U. S. Regional Pasture Research Laboratory, the Forage and Range Research Branch, ARS, the Cooperative State Research Service, USDA, and the American Seed Trade Association.

Breeding and evaluation for four forage species were conducted in programs in eight Northeastern states and the U.S. Regional Pasture Research Laboratory. Seed production of experimental materials for strain synthesis investigations and regional evaluation studies was continued in three states for four forage species.

Regional evaluation of new synthetic varieties of forage crops—Fourth year data for performance of alfalfa varieties under two harvest managements (1960 trial series) were collected in New York and Maryland. All other 1960 trial series for alfalfa, brome grass and orchardgrass were terminated in 1964 or maintained in some states on a minimal basis for observations.

Management differentials consisting of severe and moderate cutting schedules were imposed on varieties in all 1960 trials for all species (alfalfa, brome grass, and orchardgrass). The regional summaries of this series present a comprehensive picture of current variety performance under varied management and environment within the region. The management details, in particular, contributed to the excellent results obtained.

For alfalfa, the information obtained is being used in decisions for future improved variety replacement of Narragansett and DuPuits, two varieties which have made outstanding contributions to forage production in the Northeast.

For bromegrass, the 1960 trial series has shown that second-cycle breeding and selection has increased yield potential to an equal extent to that obtained in the first cycle.

For orchardgrass, the trials conclusively demonstrated the overall production advantage of the medium maturity orchardgrass strains.

Severe management reduced yields materially for all species as compared to the moderate treatment and resulted in premature stand losses of alfalfa and bromegrass. Lesser effects were noted for orchardgrass. Earlier and more frequent harvests did not have as severe effects in southerly locations as in northern sites, however. It was tentatively concluded that management differentials of this type are not necessary to ascertain the maximum expression of genetic differences in advanced evaluation trials of varieties.

An alfalfa and a timothy trial series to test the performance of several new varieties originating at the New York experiment station were planted in the following states in 1964:

1964 Alfalfa varieties — Connecticut, Maine, Maryland, New York (6 locations), Pennsylvania (3 locations), Vermont, and West Virginia.

1964 Timothy varieties — Connecticut and Vermont.

Successful establishment of these trials at some locations is questionable because of drought conditions generally experienced over the Northeastern region in 1964.

A 15 entry orchardgrass variety trial including three nonheading synthetics developed at the U. S. Regional Pasture Research Laboratory was established in Vermont in 1964.

Cooperative forage breeding studies—Orchardgrass—Data were obtained at New York and Pennsylvania for three polycross progeny trials to evaluate the yield of 66 parental clones segregated into medium early, medium late, and late maturity groups on the basis of heading date. This series was planted in 1962 in New York, Pennsylvania, and West Virginia. Stand failures were sustained in the latter two locations, but the trial was replanted successfully in Pennsylvania in 1963. On the basis of very preliminary results, several progenies appear high in forage yielding ability and promising for use in further variety synthesis.

Bromegrass—Polycross progeny trials established in 1961 and 1962 are under evaluation at both Pennsylvania and New York. Data were obtained in 1964 for both trials at both locations. Several progenies have appeared to be high yielding in these trials, indicating high potential for the parental clones for use in new synthetic combinations.

Cooperative studies of polycross progenies from disease resistant brome-grass clones developed at the U. S. Regional Pasture Research Laboratory were continued in 1964. The parent clones of progenies under study were selected as resistant to Helminthosporium bromi and Stagonospora bromi. Polycross progeny trials were established at the U. S. Regional Pasture Research

Laboratory and New Hampshire in 1963 for evaluation of resistance to Rhynchosporium secalis. Based on the results from the two locations two synthetics were formulated and Syn 1 seed will be produced in 1965.

Alfalfa—A simultaneous evaluation of forage and seed yield potential of polycross progenies of 65 disease resistant alfalfa clones with Vernal germ plasm is underway in Pennsylvania, Minnesota, and Utah in cooperation with the U. S. Regional Pasture Research Laboratory. Data from the first harvest year were obtained from all locations in 1964.

Variety synthesis studies for perennial forages—Investigations of synthesis procedures are in progress for five species: alfalfa, birdsfoot trefoil, timothy, brome grass, and orchardgrass. Although field evaluation of experimental materials has begun for alfalfa and timothy, much of the current work is in the production of seed for future studies. The seed production phases are largely being carried out by use of isolation cages or field isolation nurseries located in New York, Pennsylvania, and New Hampshire. Seed production in 1964 was generally successful. The scope of the seed production phases is outlined below.

A. Seed Production Phases:

New York Isolation cages for:

B. F. Trefoil — 57 total; 44 (12' x 12'), 13 (12' x 20' or 24')

Alfalfa — 17 total; 7 (12' x 24'), 10 (12' x 12')

Timothy — 44 total; (8' x 16')

Plantings were made in 1964 for additional production in 1965 as follows: 24 cages Timothy; 10 cages B. F. Trefoil.

Pennsylvania — Isolation cages for orchardgrass - 32 total;

8 cages (10' x 20'); 24 cages (4' x 4')

Field isolations - Syn₁ and Syn₂ seed generations were produced for 11 synthetics constituted on regional performance.

Plantings were made in 1964 of eleven crossing blocks for the production of S₁F₁ orchardgrass seed under cage in 1965.

New Hampshire

Brome grass—Field isolation—Syn₂ generation seed of 12 single crosses was produced. Syn₁ seed of 3, 4, 5, and 6-clone synthetics was produced in 1964 and nurseries established for the production of Syn₂ seed of these in 1965.

Field and greenhouse crossing and selfing—300 to 400 selfs were made for the production of S₂ and S₃ generations of mutant marker stocks and for the production of F₂ generations of self fertile normal x mutant crosses. Numerous crosses involving mutant stocks were also made.

B. Evaluation Phases:

Alfalfa—Forage yield data were obtained in 1964 from alfalfa synthesis trials I and II at New York, and from trials III, IV, V, and VI at New York (two locations each) and Pennsylvania (one location). Early results suggest: (1) differences exist among the possible double-cross arrangements of four parent clones; (2) no differences exist in double-cross performance when double-crosses are produced using different seed generations of the single-cross parent lines; (3) there is evidence of seed production location effects on stabilized synthetic performance, and (4) evidence exists that double-crosses are no better than stabilized synthetics from the same parent clones.

Comparisons that test the significance of true double-cross seed in the double-cross seed mixture are as yet inconclusive. Seed-cage procedures as they affect amount of cross pollination and determine competition among producing genotypes have been found to affect synthesis results.

Timothy—Evaluation trials for synthesis materials were planted in New York and Pennsylvania but did not survive. Cage studies indicate about a 2-day shift toward earliness from the maturity expression of the parent clones to the S_1F_2 generations derived from the clones. A high association between maturity and seedling vigor has been noted.

Birdsfoot Trefoil—Extensive studies using the HCN gene marker have been made concerning the influence of seed cage procedure on the amount of crossing occurring during synthesis. Self-fertile clones produce selfed seed under cross pollination in proportion to their self-fertility index. Plant position in cages and row spacing influence crossing percentage. Selection for heavy seeds and tall seedlings has been found to discriminate in favor of crossed progeny as opposed to selfed and sibbed progeny.

Bromegrass— Syn_1 and Syn_2 generations of a diallel single cross test of 6 bromegrass clones were evaluated for the second year in 1964 at New Hampshire. Yields averaged about 0.4 to 0.5 ton per acre less in Syn_2 than in Syn_1 .

At New Hampshire and New York efforts are being made with the bromegrass species to obtain mutant stocks that may be used in pollen dispersal studies and other studies of a similar nature relating to strain synthesis. At New Hampshire in 1964 the second year's data of a pollen dispersal trial was collected. In this trial two yellow (chlorophyll deficient) clones were planted at distances from 3 feet up to 403 feet away from a green (normal chlorophyll) nursery of about 1/2 acre. Open-pollination seedlings were grown from the two yellow clones and compared for the ratio of yellow, intermediate and green plants with the actual cross of these mutants under bags. Results in 1964, as in 1963, indicated significant contamination of green pollen at the maximum available distance of 403 feet.

USEFULNESS OF FINDINGS:

Trials of polycross progenies and synthetics are a very valuable source of information concerning forage productivity, quality, disease resistance, tolerance to different managements and stand longevity. The assessment of characteristics of experimental forages, along with information about geo-climatic-genotypic interactions that may exist, is essential to the formulation of superior forage varieties with the widest possible adaptation in the Northeast. For most species, experimental varieties being studied in current trial series represent the culmination of twenty or more years of breeding research.

The seed production phases of NE-28 research were instituted for several purposes: to test breeding methodology theory; to find new means to utilize heterosis in forage plants; to devise new methods for forage improvement whereby the total time required from initiation of breeding to farmer use of improved products may be shortened. Commercial seed production of forages may be facilitated through improvements in efficiency and lowering of costs if practical new techniques of variety synthesis and seed production can be devised. Genetic studies utilizing mutants found in brome grass offer promise for better understanding of the modes of inheritance in this species.

The release of several forage varieties by state experiment stations of the Northeastern region has been facilitated by performance information gathered from experiments under this project:

- (1) Alfalfa. Saranac and Cayuga have been released. Three other experimental varieties have high potential and are under consideration.
- (2) Orchardgrass. Pennmead, a high yielding, persistent, medium maturity variety was released in 1963.

Title: PROJECT NE-29 - MORPHOLOGICAL AND PHYSIOLOGICAL RESPONSES OF PERENNIAL FORAGE GRASSES

Leader: M. J. Wright, Chairman, Regional Technical Committee

Cooperators: The 12 Northeastern States, The Forage and Range Research Branch, the U. S. Regional Pasture Research Laboratory, ARS, and Cooperative State Research Service, USDA.

The present project outline embraces three objectives:

1. To determine the effects of management and environment on the morphological development and growth rate of perennial forage grasses.
2. To study factors influencing the accumulation and depletion of food reserves in perennial forage grasses.

3. To establish the nutritional value of forage samples representative of specific management systems.

Accomplishments under these objectives were:

Objective 1. In morphological studies on timothy, the rate of stem elongation was found to be most rapid during two five-day periods separated by five days (Pennsylvania); the production of heads per square foot was influenced by rate and timing of nitrogen fertilization in both first and second growth (Rhode Island):

First Growth Cycle					Second Growth Cycle	
Nitrogen treatment schedule (lbs N/ac)				Headed	Nitrogen	Headed
Early	20 days,	10 days,		tillers	lbs/ac.,	tillers
spring	pre-cut	pre-cut	Subtotal	/ ft ²	Post cut 1	/ ft ²
25	0	0	25	24.7 bc*	25	1.3 c
25	50	0	75	27.3 bc	75	13.3 b
25	0	50	75	25.1 bc	75	19.6 a
75	0	0	75	45.3 a	75	2.6 c

*Values within a column are not significantly different ($P=0.05$) if followed by the same letter.

Reed canarygrass was measured in the field at frequent intervals during the first growth at two stations. In Pennsylvania its stems elongated most rapidly during the same two periods mentioned above, but its pace was more variable and it reached the boot stage sooner, on the average, than timothy. In Connecticut large, dominant "reference" plants were measured and weighed in detail. Efforts to develop a maturity guide from these figures were unproductive, but definitions of stages were attempted. At both stations fruit fly damage to shoot apices was common and severe enough to jeopardize morphological and physiological experiments.

Studies of stem units (New York) led to the conclusion that new rhizomes, old rhizomes, and culm bases of reed canarygrass differed in anatomy, in carbohydrate content, and in ability to support shoot development in competitive situations. The old rhizome appeared to store the most carbohydrate and contribute most to development of shoots from other kinds of stem units, but buds arising from old rhizomes were at a competitive disadvantage. By selectively defoliating a tiller and/or the shoot from which it arose, it was possible to demonstrate that there was little or no interdependence for photosynthate.

Growth rate of potted plants of orchardgrass, brome grass, timothy and Kentucky bluegrass was studied under field conditions at four locations, with and without supplemental irrigation and fertilization (West Virginia). When yields were compared it was found that irrigation sufficient to

maintain the weekly water input at 1 inch or more removed a major limitation to growth, but location effects were also significant, as were fertility effects. Bromegrass yields were more uniform than the others. In another factorial experiment (Connecticut) drought prevented normal responses.

Both first and second aftermaths of Climax timothy were greater following cuts made at less mature stages, and total growth for the season was greatest when the first two cuts were made at a "full head" stage 10 days after late boot (Rhode Island). Stubble heights of 1, 2-1/2, and 4 inches were established late in 1964 in Maine and results will be evaluated in 1965.

A new experimental facility at Maryland was operated in 1964 to test the influence of controlled soil temperature on the growth of orchardgrass under different shading and nitrogen fertilization treatments. The degree of control for the 1.5 to 12-inch soil depth was extremely good throughout most of the summer. This control was best at 70° F, followed by 50° and then 90°. Total dry matter production between June and the end of the season was highest where soil temperature was uncontrolled or held at 70°. A soil temperature of 50° was more beneficial during the hottest months than a temperature of 90°. Toward the end of the season the 50° treatment appeared to induce dormancy, especially under low nitrogen. Effects of shading on yield were most pronounced at 70°, and least at 90°. Tillering was promoted by low temperature and low level of nitrogen fertilizer.

Objective 2. Carbohydrate reserves in reed canarygrass stubble were observed to fluctuate diurnally, with sucrose and fructosan reaching maxima, and free sugars a minimum, near midday. Seasonal fluctuations included a sharp drop in the predominant constituent, fructosan, between January and March, followed by a minor uptrend in April and a prolonged period of low levels. A rapid rise occurred in the middle of June. At a lower rate of nitrogen fertilization, the depression of fructosan values was somewhat less marked. The free sugar and sucrose components varied individually. The major minima of fructosan corresponded with the prejoint and late boot-early heading stages (Connecticut). In studies involving removal of individual blades from shoots of reed canary, total available carbohydrate values fell and nitrate concentrations rose with increasingly severe defoliation as defined in earlier experiments. Etiolated regrowth and nitrate content were positively associated with nitrogen fertilization in sand culture but not in soil (New York).

Carbohydrate reserves in orchardgrass stem bases were depressed by nitrogen fertilization, close cutting, and hot weather (Massachusetts). It was observed that a delay in harvesting may jeopardize recovery and even survival, probably because hot weather is more likely during the post-harvest period. Etiolated regrowth of timothy (Rhode Island) after first harvest did not reflect previous treatment, but a favorable after-effect of late first harvesting was seen in etiolated regrowth from plugs collected after second harvest. Heavy post-first-harvest application of nitrogen, on the other hand, depressed the amount of etiolated regrowth from such plugs.

Objective 3. Quantities of forage sufficient for feeding trials were produced under schedules representative of the previous NE-29 project. Timothy was

produced under three such schedules in Maine, three in Vermont, and four in Rhode Island. In Connecticut small samples of reed canarygrass were subjected to proximate analysis, and estimated net energy values on these samples were obtained at West Virginia by an in vitro method.

Other accomplishments:

Pennsylvania prolonged the former NE-29 forage management trials on two orchardgrasses and reed canary in an attempt to compensate for the unfavorable seasons of 1962 and 1963, but 1964 was also droughty. The order of seasonal mean production was Pennlate > Potomac > reed canary. Treatment effects were in line with previous experience.

Title: PROJECT NE-43R - PROFITABILITY OF ALTERNATIVE FEED HANDLING METHODS ON NORTHEASTERN DAIRY FARMS

Leader: J. P. Marshall, Chairman, Regional Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations, ERS-NE, N. H. Farm Prod. Econ. Div.; Cooperative State Research Service, USDA

All the participating states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Jersey, New York and Vermont) completed the first data collection phase, which began September 15, 1963 and continued for 13 months. A research committee on procedures and methodology had established the kind and form of data to be collected and during the year this committee prepared coding instructions applicable to the data collected (1) on the initial survey (of cooperating farms that was started after July 1, and completed prior to September 15, 1963), and (2) one day per month from each cooperating farmer during the 13-month data collection period. The coding and punching of all initial survey data was completed by all participating states and each participating state has received a complete set of the initial data. Recommended changes were being incorporated into the second coding instruction at the end of the year.

Relatively large time and cost differences in feed handling methods have been observed in the data collected. As a result several stations started to collect time and motion data following completion of the 13-month period to obtain data on specific feed handling methods for use in the final phase of the study.

An outline for a regional publication was prepared. Several publications contributing to NE-43R were completed by participating stations.

The data will be analyzed for the regional report. Dairymen will be able to obtain data relevant to specific feed handling methods for silage, concentrate and hay. The results of the study can provide the basis for decisions

by dairymen to improve their business efficiency and profitability through a reduction in the combined costs of labor used and total investment in feed handling equipment.

Title: PROJECT NE-45 - ROOT AND CROWN DISEASES OF ALFALFA AND CLOVERS

Leader: R. L. Miller, Chairman, Regional Technical Committee

Cooperators: Delaware, New Jersey, New Hampshire, New York, Pennsylvania, Rhode Island, and West Virginia Experiment Stations; the U. S. Regional Pasture Research Laboratory, the Forage and Range Research Branch, ARS; and Cooperative State Research Service, USDA.

Causes of root and crown diseases of alfalfa and clovers—In New Hampshire Fusarium oxysporum was isolated most frequently from diseased white clover roots. F. solani, F. roseum, Gliocladium roseum, Leptodiscus terrestris, and species of Trichoderma, Chaetomium, Phoma, and Rhizoctonia also were found associated with rotting roots. Pathogenicity tests with these organisms on 4- to 7-month-old plants grown in agar impregnated with nutrient solution are underway.

The effects of F. oxysporum f. sp. medicaginis on 6 strains and varieties of alfalfa were determined at the Pasture Research Laboratory. The alfalfa selections differed in susceptibility; 20% of the plants of mass selection A (developed in North Carolina) were killed whereas 53% of the plants of DuPuits were killed.

In Pennsylvania, Pennscott red clover roots showed severe root rot 8 weeks after they had been inoculated with F. roseum.

The pathogenicity of each of F. roseum, F. solani f. sp. phaseoli, F. oxysporum f. sp. batatas, F. oxysporum f. sp. lycopersici, F. oxysporum f. sp. cubense, F. oxysporum f. sp. niveum and F. oxysporum f. sp. melonis was tested on red clover roots in Delaware; F. oxysporum f. sp. batatas caused the most cortical rot. Macrophomina phaseoli in partially sterilized soil caused root rot of red clover in greenhouse tests.

In New York, additional evidence was obtained that Fusarium sp. isolated from alfalfa roots are relatively more pathogenic to alfalfa than are isolates of other genera. A total of 67 isolates of representative fungi isolated from alfalfa roots over a 3-year period were tested for pathogenicity on 5-day-old alfalfa seedlings by means of a test tube technique reported in the literature. The 49 isolates of Fusarium tested were found to be highly pathogenic. Isolates of Phoma and Mucor also were pathogenic but to a lesser extent than Fusarium. Other genera tested (Penicillium, Alternaria, Trichoderma, Aspergillus, Rhizopus, Zygorhynchus, and Colletotrichum) were relatively avirulent to alfalfa seedlings.

Laboratory and greenhouse tests made in West Virginia showed that the degree of seedling damping-off caused by a single fungus may not be correlated with the rapidity or degree of disease development that results from inoculation of older plants with the same fungus. A quick seedling test for pathogenicity, therefore, does not appear to be practical.

In Delaware, Pennscott red clover roots developed greater root decay as a result of inoculation concurrently with Meloidogyne incognita acrita and an isolate of Fusarium than did roots that were inoculated singly with either pathogen.

In Pennsylvania, concurrent inoculation of roots of Pennscott red clover with Meloidogyne incognita and Fusarium roseum did not result in significant increases in root deterioration over that which occurred when the roots were inoculated singly with F. roseum.

Preliminary studies are underway in West Virginia to determine the viruses that are prevalent on alfalfa and red clover. Virus diseased plants will be utilized to determine whether virus infection may be a factor that predisposes the plants to root rot.

At the Pasture Research Laboratory, research concerned with internal breakdown (IB) of red clover was continued in 1964. Polycross progenies of F_4 selections for resistance had an incidence of 9% IB; F_2 plants selected for susceptibility had 80% IB; and 42% of seedlings of nonselected Pennscott developed IB. Irradiation with thermal neutrons of seed and seedlings of red clover caused a slight increase in incidence of IB. In 2 other experiments involving as variables daylength, temperature, clipping severity, and 1 and 3 plants per 4" pot, highest incidence of IB was recorded for those treatments most favorable for plant growth (i.e., low temperature, lenient clipping, 1 plant per pot). Treatments that resulted in larger plants (larger taproot diameters) also resulted in a greater incidence of IB. IB appeared to be an indirect effect of the treatments.

Many greenhouse tests have been conducted over the past several years to determine the cause of IB. Variables that were tested included soil mixes varying in physical structure and fertility, minor elements, various major-element ratios, seed of various ages, varieties of red clover, soil moisture levels, inoculations with fungi, bacteria, and viruses, CO_2 concentrations at the crown, sugar concentrations in the crown. In all of the tests, incidence of IB was not affected directly by the treatment; however, plants from treatments that favored growth appeared to have more IB. To elucidate this point, data from all previous experiments were pooled and examined in terms of the relation of root diameter and age of plant to percentage of IB. Plants with the same taproot diameter, regardless of chronological age (4 months to 9 months), had approximately the same incidence of IB. Field plants ranging in age from 4 months to 30 months that had the same root diameter also had approximately the same amount of IB.

Interactions of the Physical Environment and the Ecological Succession of Parasitic and Nonparasitic Microorganisms in the Development of Root and Crown Diseases

In Pennsylvania, DuPuits alfalfa and Pennscott red clover were grown under different soil moisture stress regimes, i.e., constant saturation capacity (SC), SC-field capacity (FC)-SC, FC-permanent wilting percentage (PWP)-FC, and constant PWP by means of a split root system. After 60 days under the assigned stress regimes, the soil masses were eluted with 80% ethanol, concentrated under vacuum, and separated into amino acid and nonamino acid fractions by passing them through charged resin filters. The nonamino acid fractions of root exudates from red clover grown under the SC-FC-SC, FC-PWP-FC, and constant PWP regimes completely inhibited the hatching of Meloidogyne incognita eggs. Similar fractions from alfalfa root exudates produced at FC-PWP-FC and constant PWP also inhibited egg hatch.

Work in New Jersey has shown that various Fusarium spp. colonize the roots of very young clover seedlings. An investigation was initiated to evaluate the significance of the monosaccharides released by the roots of seedling red clover plants on spore germination and mycelial growth of fungi implicated in the decline of red clover. The carbohydrate fraction of the exudate from clover plants grown aseptically as test tube cultures for 12 days has been analyzed chromatographically by multiple descending development employing as a solvent system 1-butanol-pyridine-water (6:4:3). The following sugars were identified as components of the exudate: glucose, fructose, galactose, ribose and xylose. Two additional carbohydrates with low R_g glucose values were consistently observed; these compounds have not been identified but they presumably are oligosaccharides or sugar derivatives. The μg of a given sugar released per 12-day-old seedling was glucose, 4.10 ± 0.29 ; fructose, 2.07 ± 0.44 ; ribose, 1.60 ± 0.49 ; galactose 1.26 ± 0.29 ; xylose, trace.

Laboratory and greenhouse studies were conducted in Rhode Island to verify the observations that environmental "stresses" or factors appear to influence initiation of infection and disease development. The nuclear condition in hyphal tips of Fusaria is capable of being changed. Hence, growth habit and parasitic potential are modified. Some 62 named species and isolates were examined with the phase contrast microscope. Tip cells varied from 1 to 27 nuclei, depending upon species and host isolate. After a septum is formed nuclei were never found to pass through it in F. oxysporum. The average number of nuclei can be significantly changed by varying the concentration of certain nutrients (e.g., dextrose, potato extract, etc.), pH of environment, presence of IAA and some fungicidal chemicals. Indications are that some Fusaria are unstable and their ecology affects their physiology.

In New York, studies were continued in 1964 on pectolytic enzyme production by isolates of Fusarium sp. and by other genera of fungi isolated from alfalfa roots. The Fusarium sp. (F. oxysporum, F. solani, F. roseum, and F. tricinctum) tested were as a group capable of consistently producing in vitro high levels of polygalacturonate trans-eliminase (PTE). Of the other genera tested, only certain isolates of Aspergillus, Alternaria, Gliocladium and Penicillium apparently were capable of producing PTE. Although the Fusarium sp. tested had the capacity to produce endopolygalacturonase (PG), the extent to which this enzyme was produced varied markedly.

Factors associated with the time of the year when the roots used to culture the fungi are harvested from the field apparently influence the amount of PG produced but have little or no effect on production by the isolates of PTE. A differential effect of Ca^{++} on the activity of Fusarium PG (inhibited) and PTE (stimulated) was demonstrated. Activity of Fusarium PTE was characterized in terms of substrate preference, optimum pH for activity, influence of various cations on activity, and macerating ability.

The production of pectolytic and cellulolytic enzymes by Fusarium roseum, F. solani, and Meloidogyne incognita was investigated in Pennsylvania. Assays for the in vitro production of pectolytic and cellulolytic enzymes by F. solani were performed by viscosity, colorimeter, pH, and maceration tests. Enzymes produced were polygalacturonase (PG), cellulase (C_1), pectin depolymerase (DP), and pectin trans-eliminase (PTE). Homogenized preparations of Meloidogyne incognita failed to yield pectolytic or cellulolytic enzymes. Roots of Pennscott red clover infected with F. roseum alone contained PG, C_1 , PME, PTE, and protopectinase. Infections with M. incognita alone yielded possibly PTE, but no other enzymes. When roots of Pennscott red clover were infected concurrently with F. roseum and M. incognita no difference in types of enzymes produced by either organism in single infections was detected. However, there was an apparent increase in the activity of PTE.

In West Virginia, relatively little difference was found in the numbers or kinds of fungi associated with roots of red clover and alfalfa grown in plots to which the following treatments had been applied 1 year previously: insecticide, fungicide, nematocide, fumigant, no treatment. Recontamination of fumigated areas by root rot pathogens appears to be sufficiently rapid to nullify the effectiveness of this extreme treatment within a few weeks. Greater than average numbers of plants survived in nematocide-treated plots and fewer but larger than average plants were found in fumigated plots. The population of nematodes associated with roots of young alfalfa and red clover plants from the variously treated plots and with roots of 4-year-old DuPuits alfalfa plants was predominately free-living but the parasitic nematode population was considered to be large enough to cause damage when combined with other factors.

In New Hampshire, ladino white clover grown in the greenhouse and in the field was cut to heights of 1", 2" and 4" above soil level. Close cutting (1") favored the development of root rot more than did the 2" cut. Root rot of plants grown in the greenhouse was consistently decreased as the height of cut was increased, but no consistent differences were found for plants grown in the field. In greenhouse studies root rot of red clover followed the same trend as that recorded for root rot of white clover.

In Delaware, longevity and number of alfalfa plants were not significantly different for any of the crop rotation plots. As in 1963, the best stand of red clover was in the plot previously cropped successively to corn. The poorest stands of red clover occurred in the plots that had been cropped continuously to crimson clover, soybeans, or tomatoes. The latter plot in previous years had a high infestation of Fusarium oxysporum f. sp. lycopersici. This fungus appears to be similar to F. oxysporum f. sp. batatas which in turn is very similar to the Fusarium isolates most commonly obtained from red clover roots growing in plots previously cropped continuously to soybeans.

An experiment was conducted at the Pasture Research Laboratory to determine the effects of Fusarium oxysporum f. sp. medicaginis on 6 strains and varieties of alfalfa grown in a sand medium at high and low K levels. At the low K level, plant dry weight and the percent K in the plant tops was reduced. Disease development did not differ for the 2 levels of K.

A final analysis of results of a study initiated in New York in 1961 was completed in 1964. Additional evidence was obtained that root rot and lack of persistence of alfalfa increase under conditions of low K fertility, increased cutting frequency, and severe foliar infection. Data were obtained that suggest Fusarium sp. (especially F. oxysporum) are a primary factor in the development of alfalfa root rot. This fungus showed the greatest response in numbers isolated in terms of the root fraction (steler, cortical or fibrous root tissue) sampled, the time of year when sampled (highest in the summer) and the degree of root rot present. It was found to colonize seedling roots as early as 3 days after seeding, was among the first fungi to penetrate the inner-root tissues, was isolated with increased frequency as cutting frequency or foliar infection was increased, and was recovered with greater frequency from plants under low K fertility than from plants under high K fertility.

Ten strains of white clover were evaluated in New Hampshire for root rot resistance. Although varying degrees of resistance were found, no strain appeared to be consistently more resistant than another.

USEFULNESS OF FINDINGS:

It has been established on a regional basis that certain Fusarium sp. apparently are a significant factor in both alfalfa and clover root and crown rots. These fungi colonize seedlings almost as soon as the seed germinates. They are capable of developing in a parasitic relationship with the root tissues without causing any readily apparent damage to the tissues. Whether or not their potential as pathogens is realized appears to be subject to the influence of a variety of factors. These factors appear to be involved in the role of stresses on the plant and pathogen such that root rot occurs. That a variety of factors may act in this way is indicated by the findings that soil insects, fertility levels, intensive cutting, foliar infection, apparently influence development of root and crown rot. This knowledge will permit a concerted effort to determine more critically the role of stress factors in relation to the Fusaria in the development of root and crown rot. Moreover, it provides a basis for consideration of management practices that will result in significant reductions in the incidence of the root and crown rot.

Tests that demonstrated a lack of resistance in strains of white clover to root and crown rot indicate that some other approach to control may have to be utilized.

The findings related to the production of cell wall degrading enzymes by the Fusaria offer a possible explanation of the mechanism by which the Fusaria cause root and crown deterioration. Information on the properties of the enzymes and the influence of various factors on their activity may provide a possible approach to control of the organism.

Information on the nature and influence of root exudates on microbial activity (both fungi and nematodes) may provide a basis for understanding how various factors of the physical environment may exert their effect on the development of the disease through their role in modifying the nature of the root exudate.

The information obtained concerning internal breakdown (IB) indicates that it is a physiogenic disease of red clover. Red clover is heterozygous for expression of IB which is influenced by environmental factors that favor rapid growth. The incidence of the disease appears to be correlated with size of the root-crown junction area. Knowledge of the disease indicates that resistance may be obtained in a breeding program.

PASTURE RESEARCH AT STATE STATIONS

CONNECTICUT (STORRS)

Title: ALFALFA PHYSIOLOGY

Leader: D. D. Wolf

1. Fate of metabolites during winter--Single plants of six alfalfa varieties were exposed to radioactive carbon dioxide during late fall of 1964. Plants were harvested several times during late winter of 1965. Measurements of storage organ included respiration of root tissue slices, total activity remaining, activity in acid soluble extract (TAC) and activity in nonacid soluble tissue.
2. Translocation of radioactive sugars--Clonal propagates of reed canarygrass and spaced alfalfa plants were fed radioactive glucose and fructose. Two days later the plants were harvested and activity in the various portions of the plants were assayed for distribution of activity which would indicate translocation. Column chromatographic separation of the plant sugars will be made to determine whether the sugars were metabolized before translocation. Results from completed analysis indicate that sugars are translocated through the system of a reed canarygrass clone and of an alfalfa plant. Sugar foreign to that normally stored in the plant (glucose in reed canarygrass and fructose in alfalfa) was translocated more extensively than was the sugar normally stored.
3. Effects of environmental conditions on plant responses--Equipment has been assembled to simulate various environmental conditions under field conditions. A portable controlled environmental chamber is used to expose plants to radioactive carbon dioxide. Analyses of plants give relative rates of photosynthesis, photosynthate accumulation, and photosynthate depletion.

Title: REED CANARYGRASS MANAGEMENT

Leader: D. D. Wolf

1. Frit fly damage--Biweekly chemical applications controlled symptoms of frit fly infestation while practiced in early spring. Infestation occurred in midsummer after spray schedules were discontinued. Damage was observed as flagging of the uppermost unfolding leaves. Dissection of the plant revealed larvae just above the injured growing point.

2. Column chromatographic separation of stored sugars--Procedures for separation and analysis of free sugars have been established. Rhizomes have been collected at monthly intervals throughout the fall (1964) and winter (1964-65) and preliminary analyses show major shifts in total amounts of free sugars as well as relative amounts of sucrose, hexoses and pentoses.

Title: THE SELECTIVE CONTROL OF ANNUAL GRASSES IN NEW SEEDINGS OF PERENNIAL GRASSES

Leader: R. A. Peters

A new substituted urea compound, 1-(2-methyl cyclohexyl-3-phenyl), has shown unique selectivity in killing annual weedy grasses in seedings of perennial turf and forage grasses. This chemical, known as tuperson, was applied as a pre-emergence spray immediately after seeding at rates of 4 pounds of actual material per acre.

Broadleaf annual weed control is rather limited but either clipping or a delayed application of 2,4-D will control these weeds.

Alfalfa has shown considerable tolerance to tuperson in experiments at Storrs. Tuperson should be evaluated further for use in establishing alfalfa-forage grass seedings.

MARYLAND

Title: RESPONSE OF MIDLAND BERMUDAGRASS TO TWO SOURCES OF NITROGEN, THREE RATES OF NITROGEN AND THREE LEVELS OF LIME

Leaders: A. M. Decker and J. H. Axley

A uniform planting of Midland bermudagrass was fertilized for the third year with 200, 600 and 1800 lbs N per acre with both ammonium nitrate and ammonium sulfate sources. Liming treatments were no lime, theoretical amounts to correct nitrogen acidity, and twice the required lime to correct acidity. Dry matter yields ranged from 0.61 tons with no nitrogen to 5.05 with 600 lbs N plus lime. Yields increased up to 600 lbs of N per acre but were actually lower at 1800 lbs N in some cases. The addition of lime at all levels of nitrogen increased dry matter yields even though pH was not entirely corrected. Wherever the pH was lowered because of nitrogen fertilization or lack of adequate lime, garlic infestation was reduced. This weed infestation was heavy on the low nitrogen or high lime plots.

Title: SOD SEEDING ESTABLISHMENT STUDIES

Leader: A. Morris Decker

Sod-seeding studies on Midland bermudagrass were continued for the third year (1963 Annual Report, page 43). Total yields increased with each increment of added nitrogen. Data further indicate that at least 400 lbs of N per acre are required to provide satisfactory growth of both the summer growing Midland and the sod-seeded winter annual. For the first time in the study, summer production of Midland was reduced by the fall sod-seeded crop. Excellent spring growing conditions followed by a dry summer provided good moisture for the sod-seeded crop but very little for the Midland so that it got off to a very slow start.

Sod-seeding of a small-seeded legume into a grass-dominant bluegrass pasture was continued. The disk type opener along with a spear-point for banding fertilizer below the seed was again superior. A study has been initiated to compare the productive capacities of sod-seeded pastures, nitrogen fertilization pastures, and completely renovated pastures for improving existing permanent bluegrass areas.

Title: DIFFERENTIAL HARVESTING MANAGEMENT OF RED CLOVER AND RED CLOVER - TIMOTHY STANDS UNDER THREE LEVELS OF FERTILIZATION

Leaders: A. Morris Decker and L. R. Wade

Chesapeake red clover and Chesapeake - Clair timothy mixtures were seeded in the spring and fall of 1963. A second seeding was made in 1964. Dry matter production of the 1963 seeding was made during the 1964 growing season. Yields looked extremely good in terms of forage yield and quality. Yields were increased with increased fertilization (0-15-30) and with the addition of timothy. Harvesting at a more immature stage of growth (bud and early bloom) did not materially reduce yields from those obtained at full bloom but did improve forage quality. Forage yields on the better treatments were nearly 5.0 tons per acre making red clover a strong competitor with alfalfa.

Title: PASTURE EVALUATION USING BEEF STEERS

Leader: A. Morris Decker

Midland bermudagrass pastures established in 1963 were uniformly grazed in 1964 and sod-seeded with cereal rye in October, 1964. Forty-two choice Angus steers were purchased in October 1964, and uniformly wintered. The steers will be used to evaluate Midland bermuda-sod-seeded pastures at two nitrogen levels and will be given two levels of grain feeding while on pasture. This study was to have begun during the 1964 grazing season but this was not possible because of extensive drought.

Title: FERTILITY AND CLIPPING MANAGEMENT EFFECTS ON THE PRODUCTIVITY AND PERSISTENCE OF ANNUAL PASTURE GRASSES

Leader: N. A. Clark

Sudangrass was grown at plant spacings from 1 x 1 to 16 x 16 inches and evaluated for quality by chemical analysis. Results showed that at first harvest the quality decreased as the population increased.

Nitrate accumulation in pearl millet and sudangrass was also investigated. Based upon one year's work the nitrate content was substantially higher in the pearl millet than in the sudangrass. The nitrate was well below lethal levels, however.

Title: THE EVALUATION OF SUMMER ANNUAL PASTURES FOR LACTATING DAIRY COWS

Leaders: N. A. Clark, R. W. Hemken, J. H. Vandersall

Piper sudangrass and Gahi No. 1 pearl millet were compared as summer annual pasture for dairy cows. These pastures were equal in dry matter production, animal carrying capacity, and amount of milk produced. As in previous years, butterfat production was significantly lower in cows grazing pearl millet than in cows grazing sudangrass. Certain additives were fed to cows on pearl millet in an attempt to alleviate fat depression. Some of these appear to have promise, but results to date are inconclusive.

Title: DEVELOPMENT OF ALFALFA RESISTANT TO SCLEROTINIA ROOT AND CROWN ROT

Leaders: O. D. Morgan and E. H. Beyer

Eleven selections of Medicago falcata, two of M. pironae, one of M. platycarpa, one of M. tianschanica, one M. sativa var glutinosa, four M. sativa var gaetula, three M. sativa var varia, four M. sativa selections, and one M. sativa var Williamsburg, one var Narragansett, and one var Culver. There were 30 alfalfa species, varieties and selections used in the screening tests in the greenhouse. Fifteen seed of each plant were distributed over each of 9 six-inch pots. The pots were divided into lots of three, each lot to be inoculated; lot 1 at 2 months, lot 2 at 3 months, and lot 3 at 5 months. Approximately one-third of the seed did not germinate or were lost before the first inoculation. Plant counts were made one month after inoculation. Data taken were based on 10 plants per pot. Since one pot of each plant was not inoculated lot 3 had only 2 pots for each plant. The survivors from the greenhouse were transplanted to the field. Results of last count in greenhouse, May 22, 1964 and last count in field, October 21, 1964 are shown in Table 1.

Table 1. Results of screening alfalfa species, varieties and selections for resistance to species of *Sclerotinia*, the cause of root and crown rot.

	Greenhouse	Field*
	<u>Percent surviving</u>	<u>Percent surviving of total before inoculation</u>
<u>M. falcata</u>	22.3	15.0
<u>M. pironae</u>	8.1	5.0
<u>M. platycarpa</u>	2.5	1.25
<u>M. tianschanica</u>	36.2	22.50
<u>M. sativa</u> var <u>glutinosa</u>	17.5	5.0
<u>M. sativa</u> var <u>gaetula</u>	42.5	25.6
<u>M. sativa</u> var <u>varia</u>	27.0	15.4
<u>M. sativa</u>	30.0	16.0
Williamsburg	28.8	15.0
Narragansett	41.2	29.0
Culver	35.0	21.5

* The final count will be made in May 1965.

Seed will be saved from the survivors of plants during the summer of 1965. Results show that M. tianschanica, M. sativa var gaetula, and M. sativa var Narragansett have a fair amount of resistance during the first testing period.

Total losses from all species, varieties, and selections from the plants inoculated after 2 months growth from lot 1 were 76.3%, from lot 2 inoculated after 3 months growth losses were 51%, and losses from lot 3 inoculated after 5 months growth were 58%. Some individual species M. pironae and M. platycarpa showed no statistical differences with respect to age of plants when inoculated. M. tianschanica had considerably more survivors when inoculated earlier at 2 months than at either 3 or 5 months. The rest of the alfalfa listed generally had more plants surviving in older growth than in young growth. Counts on the above test were made about 4 weeks after inoculation. It is significant to note that none of the species, varieties or selections were killed off 100%, indicating some tolerance or resistance present in all alfalfa tested.

Title: HOST PREFERENCE OF ALFALFA WEEVIL, *HYPERA POSTICA* (GYLL.) IN
RELATION TO PLANT PRODUCED ATTRACTANTS AND REPELLENTS

Leaders: A. L. Steinhauer, H. D. Byrne, R. E. Menzer and C. C. Blickenstaff
(USDA)

Steam distillation of fresh alfalfa followed by ether extraction of the distillate and subsequent collection of all volatile materials vaporizing between 35°C and 98°C has yielded a crude extract that is repellent to alfalfa weevil adults. On dilutions of this extract to 0.025% of its initial concentration

it has proven to be attractive to alfalfa weevil adults. Current work centers about the purification and identification of the components of this extract, plus assay of the individual components for their attractancy or repellency to alfalfa weevil.

Title: APPLICATION OF ENERGY FOR CONTROL OF INSECTS

Leaders: W. L. Harris, A. L. Steinhauer, N. A. Clark and C. C. Blickenstaff (USDA)

This project was inaugurated in the fall of 1964 to study the possibility of controlling the alfalfa weevil with flame cultivation. Preliminary laboratory results conducted during the winter of 1964-65 have indicated possible amount of heat necessary to be applied to alfalfa for the control of the weevil. Field studies are underway to evaluate the method for insect control, weed control, effect on the alfalfa crop and other possible application.

Title: BIOLOGY AND CONTROL OF THE ALFALFA WEEVIL

Leaders: A. L. Steinhauer, V. E. Adler (USDA) and C. C. Blickenstaff (USDA)

Studies with insecticides for the control of alfalfa weevil larvae in the spring have yielded the following materials which show promise as future control recommendations.

<u>Insecticide</u>	<u>Rate/acre</u>	<u>Effectiveness of control based on damage</u>
		<u>to alfalfa 20 days after treatment</u>
		%
Geigy G.S. 13005	12 oz	96
Imidan	24 oz	93
Geigy G.S. 12968	12 oz	91
Shell SD 7438	16 oz	91
Bayer 25141	16 oz	93

No chemicals indicated any value as fall treatments.

Studies indicated that early cutting can be beneficial in reducing numbers of weevils, but it is not effective without an insecticide treatment of the stubble.

Title: FALL VERSUS SPRING APPLIED NITROGEN FOR ORCHARDGRASS

Leader: C. B. Kresge

Nitrogen can be applied late in the fall for good orchardgrass production the next spring. Certain conditions are necessary, however. The soil temperature must have fallen below 42°F at the time of nitrogen application and must remain below that temperature until spring. Also, an ammonium source of nitrogen, such as urea or ammonium sulfate, must be used. These conclusions were derived from evaluation of the results of a 3-year study conducted on the Plant Research Farm (1961 Annual Report, page 46). The 42°F soil temperature was usually reached by December 15 and, on one occasion, by November 22. Some of the nitrate portion of ammonium nitrate applied at these dates apparently was leached out of the soil over the winter. Although the yield response to fall application of ammonium sources of nitrogen was not significantly lower than that to spring applied nitrogen, the nitrogen content was lower in the fall fertilized forage. This disadvantage would have to be weighed against the advantages of fall fertilization.

Title: EFFECT OF DIFFERENTIAL FERTILIZATION ON THE GROWTH AND DEVELOPMENT OF ALFALFA

Leaders: C. B. Kresge, D. F. Champion, and V. A. Bandel

Phosphorus is needed for fast growth of alfalfa seedlings. Treble superphosphate, diammonium phosphate, and ordinary superphosphate were banded or broadcast with banded or broadcast alfalfa seed, respectively (1963 Annual Report, page 42). No significant differences in seedling establishment among phosphorus sources were found. Early growth of alfalfa receiving no applied phosphorus was markedly inferior to that of plants receiving adequate phosphorus. Band seeding resulted in faster initial growth than that of alfalfa which was broadcast seeded. However, when phosphorus supply was inadequate, this advantage was only temporary.

Winter survival of alfalfa is often increased by potassium fertilization. A field investigation has been initiated in an attempt to find out why this occurs. Williamsburg alfalfa has been grown for 2 years under normal cropping conditions for hay. Potassium has been applied differentially according to the following annual rates of K: 0, 10, 20, 30, 40, 50, 60, 80, 100, 130, 160, and 240 lbs per acre. Roots are being sampled periodically. Preliminary work indicates that potassium-sufficient alfalfa roots have more xylem vessels which, in turn, are larger in diameter than those found in potassium-deficient roots. Theoretically, root cells would be less susceptible to freezing injury if these conducting tissues (xylem vessels) carry a large volume of electrolytes and make up an appreciable percentage of the root volume.

Title: NUTRIENT BALANCE IN ORCHARDGRASS AS RELATED TO DIFFERENTIAL FERTILIZATION

Leaders: C. B. Kresge and V. A. Bandel

The need for balanced fertilization of grass becomes more evident when large amounts of forage are removed from the field. Dry weather during 1964 prevented high plant removal in an orchardgrass study near the Forage Research Farm (1963 Annual Report, page 41). Consequently, definite nutrient balance relationships of phosphorus, potassium and magnesium were not established. The following trends were observed: (1) a 4 to 1 ratio of applied potassium to phosphorus appeared to be optimum for maximum yields; (2) magnesium contents in harvested forage of 0.262% to 0.319% occurred when the highest yields were obtained, and (3) high rates of potassium reduced magnesium uptake sooner than they reduced calcium uptake. Future study should shed more light on these apparent relationships.

Title: RED CLOVER BREEDING INVESTIGATIONS

Leader: E. H. Beyer

Selections were made from polycross progenies at the U. S. Regional Pasture Research Laboratory. These clones may, subsequent to testing, prove to be useful in obtaining needed characteristics for a persistent red clover variety.

Work progressed in the classification of 80 Trifolium accessions. An attempt will be made to intercross selected species.

Title: FORAGE CROP VARIETY EVALUATION IN MARYLAND

Leader: E. H. Beyer

Persistence of experimental brome grass synthetics, developed at the Pennsylvania and New York Agricultural Experiment Stations, was superior to the check variety Lincoln, and to a lesser degree to Saratoga, after 4 years of testing.

Also, in a 4-year old alfalfa varietal test, DuPuits, a bacterial wilt susceptible variety, had a stand of 81%, while Vernal, a bacterial resistant variety, had a stand of 71%. Bacterial wilt was not of major consequence at this location.

First year results from a 28-entry alfalfa trial, indicated that while southwestern varieties as Moapa had superior seedling vigor and recovery after cutting, their ability to produce forage was inferior to recommended varieties. These varieties also had the greatest loss in percent stand from 1963 to 1964.

MASSACHUSETTS

Title: LEVEL OF FRUCTOSAN IN ORCHARDGRASS AS INFLUENCED BY PHYSIOLOGICAL DEVELOPMENT, HARVEST MANAGEMENT AND NITROGEN FERTILIZATION

Leaders: Mack Drake and W. G. Colby

One of the outstanding values of orchardgrass in the Northeastern USA is its rapid recovery growth after harvest and its dependable growth throughout the summer months. However, this vigorous recovery growth often is seriously impaired by some factors under intensive management. Carbohydrate reserves decrease rapidly during stem elongation and flowering. Interrelationships of weather and stage of maturity at initial harvest indicate that levels of carbohydrate reserves play an important role in the recovery growth of orchardgrass.

Research at the University of Massachusetts shows the following:

The level of fructosan in the basal tissue of orchardgrass is profoundly influenced by weather (temperature and moisture), by stage of maturity and by level of applied nitrogen, as well as by height of cutting and time of initial harvest. Fructosan accumulated rapidly in mid-May, decreased slowly and then rapidly as stem elongation began and as the head emerged and flowering developed.

Early initial harvest produced more rapid recovery of fructosan and resulted in higher levels of fructosan in the basal tissue of the second and third harvests which was also reflected in more rapid recovery growth and greater yield response to applied nitrogen.

Heavy application of nitrogen dramatically reduced the level of fructosan in the basal tissue at each of 4 harvest periods. Large applications of fertilizer nitrogen render the orchardgrass plant susceptible to injury, but the combination of high temperature and low moisture causes the injury. This injury as related to high levels of applied nitrogen was more severe with high temperature, low moisture, low height of cut, delayed initial cut and coincided with lower fructosan levels in the basal tissue.

Physiological growth and developmental response to environment results in a low level of fructosan in the basal tissue for 4 to 6 weeks following head emergence. This low level of carbohydrate reserves appears to render the plant susceptible to injury especially under high temperature, requiring skill and judgment especially under intensive fertilization and harvest management.

Title: INVESTIGATIONS OF FORAGE CROP INSECTS IN MASSACHUSETTS IN 1964

Leaders: F. R. Shaw, R. A. Callahan and F. R. Holbrook

During the growing season of 1964, collections of insects from fields of alfalfa or alfalfa mixtures were made systematically in Berkshire, Hampshire and Hampden counties with a few collections from Franklin and Worcester counties. The sampling was done from April 27 to November 24. Each sample consisted of 100 sweeps with a 15-inch sweep net. The total number of insects collected and identified was 111,817. The summarized data appear in Table 1.

Table 1. Abundance of forage crop insects in western Massachusetts, 1964.

Name of insect or group	Percent	
	of group	of total
Aphids		49.4
Plant bugs		5.2
<u>Lygus lineolaris</u>	64.6	
<u>Adelphocoris lineolatus</u>	11.1	
<u>Trigonotylus ruficornis</u>	10.5	
<u>Leptoterna dolobratu</u> s	5.4	
<u>Megalocera recticornis</u>	1.9	
Others	6.9	
Leafhoppers		10.1
<u>Empoasca fabae</u>	20.9	
<u>Endria inimica</u>	17.4	
<u>Aceratogallia sanguinolenta</u>	17.1	
<u>Errastunus ocellaris</u>	16.8	
<u>Macrosteles fascifrons</u>	7.9	
<u>Aphrodes costata</u>	6.5	
<u>Dorytura stylata</u>	4.5	
Others	8.8	
Beetles		29.8
<u>Hypera postica</u>	97.7	
<u>Sitona hispidula</u>	1.1	
Elateridae	0.7	
Others	0.5	
Spittlebug		1.3
Lepidoptera		0.7
Orthoptera		0.3
Beneficial		2.7
Coccinellidae	33.1	
Spiders and harvestmen	30.3	
Nabidae	27.4	
Chrysopidae	4.6	
Syrphidae	3.4	
Orius spp.	1.2	

Aphids, primarily Acyrtosiphon pisum, were less abundant in 1964. The pea aphid did not increase in the early season as it normally does. Most of the aphids were collected after June 20.

Plant bugs were less abundant in 1964 than previously. The tarnished plant bug was most numerous. Large populations of Plagiognathus politus, Adelphocoris rapidus and Halticus spp. did not materialize in 1964.

Leafhoppers were about normal in abundance. The potato leafhopper was not numerous in the early part of the season, up to June 20, but by fall had reached its normal abundance. Errastunus ocellaris continued to be plentiful in western Massachusetts. Macrosteles fascifrons was less numerous in 1964 than previously.

Beetles, primarily Hypera postica, showed a marked increase, amounting to almost 30% of the total population. The alfalfa weevil caused from moderate to severe damage to most untreated fields in western Massachusetts in 1964.

Spittlebugs were slightly less plentiful than usual in 1964 and were somewhat spotty in their distribution. The largest populations occurred in southern Berkshire County.

Lepidoptera were about as numerous in 1964, however, the alfalfa caterpillar was less abundant.

Orthoptera were less abundant than usual in 1964. However, some fields had appreciable numbers, particularly during late summer.

Beneficial insects were less numerous in 1964 than in other years. This may be related to low aphid populations, particularly in the early part of the season.

In addition to the investigations of populations of insects attacking alfalfa and alfalfa-grass mixtures, we made observations on the oviposition of the alfalfa weevil. These results appear in Table 2. It should be noted that the observations were made in the same field in 1963 and 1964. We carried on the investigation over a longer period in 1964 than in 1963. However, during the period of October and early November, the dates of collection were essentially the same both years.

It is evident that there was much less oviposition in the fall of 1964 than during the same period in 1963. In the comparable periods, 670 eggs were deposited in 1963 whereas only 40 were obtained in 1964.

An investigation of the numbers of weevils collected from the same field was made to see if there was a relationship between the abundance of weevils and oviposition. Our data showed that during the period of September 24 to November 19, 1963, we collected approximately 1760 weevils (all stages) including 400 adults. In 1964, during the period of September 22 to November 24, we collected 122 weevils (all stages) including 42 adults. Hence, there were definitely fewer adults in this field in 1964. The reason for this difference is not known. It appears that the migration from aestivation quarters to alfalfa in the fall of 1964 was minimal in comparison with that of 1963.

Table 2. Alfalfa weevil oviposition, New Marlboro, Mass. 1963 and 1964.*

1963			1964		
Date	No. punctures	No.eggs	Date	No.punctures	No. eggs
--	--	--	Sept 22	2	12
Oct 2	45	225	Oct 1	3	0
17	38	90	15	2	0
24	37	81	22	2	0
31	63	93	29	5	40
Nov 10	69	151	Nov 11	4	0
--	--	--	19	6	40
			24	4	16
Oct 2 - Nov 10 { Total punctures = 252 Total eggs = 670			Oct 1 - Nov 11 { Total punctures = 16 Total eggs = 40		

* Counts based on random collection of 50 stems for each date of observation.

Control of Forage Crop Insects

1. Insecticides

In 1964 we evaluated Bidrin, SD-7438, GS 13005, a mixture of diazinon and methoxychlor, methyl-ethyl Guthion, Bayer 37289, Bayer 37344, Imidan, methoxychlor and Sevin S 80 for the control of alfalfa weevil, plant bugs, leafhoppers, aphids, grasshoppers and beneficial insects. Analyses of variance were made for each of these insects or groups of insects. By the 13th day after treatment, the four best materials for alfalfa weevil control were GS 13005, Imidan, methyl-ethyl Guthion and SD-7438. By the 20th day methyl-ethyl Guthion, GS 13005, Bidrin (1.0 lb) and SD-7438 were significantly better than the other materials.

Against the leafhoppers, Sevin, Bayer 37289, Imidan and GS 13005 were not significantly better than the controls on the 13th day after treatment.

Against plant bugs there was no difference between controls and treated plots on the 13th day after treatment.

Against aphids, on the 13th day, Sevin and methoxychlor were no better than the controls. By the 20th day, Bidrin (0.5 and 1.0 lb. dosages),

Bayer 37289, GS 13005, diazinon and methoxychlor and methyl-ethyl Guthion were superior to other treatments.

Against beneficial insects and spiders there was little apparent difference in toxicity among the treatments.

Against grasshoppers, on the 13th day after treatment, Bayer 37344 was superior followed by Bidrin (1.0), methyl-ethyl Guthion, GS 13005, diazinon and methoxychlor and Bayer 37344. By the 20th day, the Bidrin treatments (0.5 and 1.0 lb) GS 13005, Bayer 37344, and Bayer 37289 were superior to the other materials at the 5% level.

2. Biological Control

In cooperation with ERD, USDA we collected larvae from a field where Bathyplectes curculionis was liberated in 1962. We also collected larvae from four other fields within a radius of four miles from the release field. Up to 21.6% parasitization occurred in the release field but in the other fields the parasitization amounted to 0.4%.

3. Pesticide Residue Studies

We sampled alfalfa from untreated fields and those treated in the fall of 1963 with heptachlor 1 lb/acre. Analyses revealed no residues in the untreated fields but up to 0.04 ppm heptachlor and 0.06 ppm heptachlor epoxide in the alfalfa from treated fields.

We also determined rates of disappearance of Cygon (Dimethoate) from alfalfa, ladino clover and birdsfoot trefoil and SD-7438 from alfalfa.

NEW HAMPSHIRE

Title: CHEMICAL CHANGES IN WILTING FORAGE

Leader: D. G. Routley

Ladino clover leaves were used for a study of the effects of excision and wilting on the alcohol soluble nitrogen compounds. Soluble nitrogen accumulated after excision, whether the leaves were wilted or not. A large part of this fraction in wilted leaves consisted of proline. The proline synthesis was stimulated when excised leaves were treated with glucose, organic acids, or light before wilting, and after these treatments it made up as much as 6% of the dry matter. Little or no proline synthesis occurred in leaves wilted under nitrogen.

Analysis of leaves of ladino clover plants wilted in the field showed that proline accumulation was not dependent upon excision. Wilting caused the soluble nitrogen to rise only slightly from 8.5% (unwilted) to 11% (wilted) of the total nitrogen. In unwilted leaves proline nitrogen made up only 2% of this soluble nitrogen but made up 30% of it in wilted leaves.

Paper chromatography has shown that the proline synthesis in attached leaves may be partly at the expense of asparagine. After wilted plants are watered however, the proline disappears faster than the asparagine reappears.

Title: THE IMPROVEMENT OF WHITE CLOVER

Leaders: G. M. Dunn and R. A. Kilpatrick

No data were obtained in 1964 from 10 diallel single crosses of ladino because of extensive drought injury. A ladino plant homozygous for filled V was selected to study pollen distribution in the field. This plant and several recessive solid green plants were planted in a polycross nursery. Seeds were harvested from the green plants to evaluate in the greenhouse.

This project will be terminated in July 1965.

Title: BREEDING OF IMPROVED VARIETIES OF FORAGE SPECIES ADAPTED TO THE NORTHEAST

Leaders: G. M. Dunn and L. J. Higgins

1963-65 average yields for 15 diallel single crosses in brome grass were 3.74 tons/acre in Syn 1 versus 3.31 tons/acre in Syn 2. Although the single crosses varied significantly in both years, much of the variance in this test was due to generations.

One interesting brome grass mutant obtained by selfing was almost completely white until late May but gradually turned green. S₂ progenies grown from this plant were practically all albino lethals in a cool greenhouse on short days, but many rapidly turned green in a warm greenhouse on a long photoperiod. This character appears to be recessive and may be useful for genetic study.

Syn 1 seed was harvested from several multi-clone brome grass synthetics. New Hampshire red clover seed was increased in the greenhouse.

Title: ROOT AND CROWN DISEASES OF LADINO WHITE CLOVER AND OTHER FORAGE LEGUMES

Leader: Avery E. Rich

Ten strains of white clover were evaluated for root rot resistance. Although varying degrees of resistance were found, no strain appeared to be consistently more resistant than the others.

Ladino white clover was cut to heights of 1", 2" and 4" above soil level in the greenhouse and in the field. Close cutting (1") favored the development of root rot more than the 2" cut. Root rot consistently decreased as height of cut increased in the greenhouse, but no consistent differences were found in the field. Root rot of red clover followed the same trend as white clover in greenhouse studies.

Fusarium oxysporum was isolated most frequently from diseased white clover roots. F. solani, F. roseum, Gliocladium roseum, Leptodiscus terrestris, Trichoderma, Chaetomium, Phoma, and Rhizoctonia were also found associated with rotting roots.

Pathogenicity tests with these organisms are under way using 4- to 7-month old plants grown in agar impregnated with nutrient solution.

NEW JERSEY

Title: ALFALFA VARIETY TRIAL

Leader: C. H. Ramage

The trial was established in 1960. Included were Atlantic alfalfa, Maliani (an Italian import), and Orchies (a French variety). Yield results for 1961, 1962, 1963, and 1964 are summarized in the following table. Three cuttings have been made each year.

Alfalfa variety trial - dry matter yields.

<u>Year</u>	<u>Atlantic</u> <u>lb/acre</u>	<u>Orchies</u> <u>lb/acre</u>	<u>Maliani</u> <u>lb/acre</u>
1961	10,259	9,049	10,127
1962	8,935	8,535	7,917
1963	10,599	10,078	10,835
1964	<u>9,567</u>	<u>8,534</u>	<u>8,490</u>
	39,360	36,196	37,369
Average	9,840	9,049	9,342

Title: SILAGE INVESTIGATIONS

Leaders: M. A. Sprague and B. B. Taylor

Summaries from 1962-1964 experiments indicate that total dry matter losses from orchardgrass made into silage were least where low (25 lb N) amounts of nitrogen fertility were applied (1.7%) and highest where 325 lbs of N was applied annually (5.2%). Similarly, orchardgrass cut at late bloom stage of maturity experienced lower (2.2%) dry matter losses than that cut at an early blossom stage (5.2%). At both early and late maturity, additional increments of nitrogen fertilizer increased the percent protein in the fresh forage. However, the early maturity treatments lost a greater percentage of protein (12%) than that harvested at late maturity (7.8%). High nitrogen levels lost 12.4% protein whereas low nitrogen fertility forage lost 7.4% of the protein during storage. Again, in orchardgrass the low nitrogen fertility level of both early and late maturity accumulated a greater percentage of total carbohydrate than the higher nitrogen fertilizer treatment. The late maturity forage lost a smaller percentage of hydrolyzable carbohydrates (26.4%) than similar forage cut at an earlier harvest (42.8%). Nitrogen fertility levels seemingly had little influence on percentage loss of total hydrolyzable carbohydrates during storage. These losses of hydrolyzable carbohydrates, however, were not losses in feed value inasmuch as they represented conversions to the fatty acids.

All silages were excellent. Accordingly, what can be measured in these tests are small differences due to maturity and fertility of the forage. Yield increases due to extra fertility or later maturity, which might contribute to higher total yields per acre, would alter the total picture with respect to available feed per acre of these different feed nutrients. In many instances, dry matter loss was decreased when percent dry matter of the fresh forage was increased, but this was only true up to about 75% moisture content, above which the reverse was true due to seepage losses. Of particular interest in every instance was that the percent moisture of the silage was greater by 1-1/2 to 2-8/10% than that of the corresponding fresh forage. It is presumed this conditional moisture represents, at least in part, water produced through chemical reaction during fermentation.

Cool temperature storage studies were extended to over-winter storage of about 8 months. Dry matter losses, pH changes, and general appearance of the stored forage were very encouraging with respect to the merit of this method of preserving forage nutrients. pH changes were up to 0.15 units; dry matter losses were unmeasurable in this 1250 lb unit.

Title: PASTURE RENOVATION

Leaders: M. A. Sprague, R. D. Ilnicki, W. H. Tharrington and M. E. Singley

Some progress was made in using certain wetting agents in combination with effective herbicides to increase the kill of unwanted species in pastures prior to reseedling. Further, a seeder was designed in principle as a single unit to prepare a 2-inch wide seedbed for precision planting of small seeded legumes and grasses in a dead sod. Three coulters serving as openers laying two 1-inch strips of sod to either side opened a furrow about 1 inch deep. Two rotary-hoe cultivators followed in the furrow to loosen the soil and provide fine soil to receive the seed. A roller presses the seed into the soil. The whole unit is designed to be assembled in tandem fashion at desired spacings to make cultivation, fertilization, and seeding a single operation.

Exploratory efforts were made in the laboratory and greenhouse on a new principle of seeding small seeds. Two to 2-1/2% solutions of agar were prepared with fungicides and the seed stirred into the cooled agar in proportions of about 1 to 1 by volume. The mixture was found to extrude well under pressure from a nozzle of a size to permit passage of the seed. In tests it was found that germination of the seed was speeded up by about 24 hours compared with seeds placed in moist soil or on wet blotters, and rapid growth of the seedlings was encouraging. Hopefully, a simple seeder can be built whereby a series of nozzles could be placed behind the coulter to place the seed at the proper depth, making use of the hydraulic system on most tractors and a roller pump to meter the seed at a desired rate. In the laboratory tests, the water absorptive capacity of the seed was such that the agar-seed mixture must be used within 2 hours in order to maintain flow properties. Legume seeds appear better suited than grass seeds to this procedure.

NEW YORK

Title: BIRDSFOOT TREFOIL SEED PRODUCTION INVESTIGATIONS

Leader: H. A. MacDonald

In an attempt to meet the critical need for birdsfoot trefoil seed production, extensive soil fertility investigations were conducted on farms within the seed producing areas of New York. Soil and seed crop samples were taken on one hundred fields in 1963. Following harvest of that year 35 replicated fertilizer trials were put out on representative farm situations. The treatments were Ca, P, K, CaP, CaK, PK, CaPK, CaPKB, and Nil. The rates of application were: lime, 4000; P₂O₅, 100; K₂O, 100 and B₂O₃, 5 lbs to the acre. Forage and seed harvests were taken in 1964 for the determination of yield and seed quality.

Laboratory tests showed the soil to have a mean pH value of 5.8 ranging from 5.1 to 6.4. Available phosphorus was uniformly very low with a mean value of 1.4 lb/acre compared to a recommended value of 6.5. More than half of the phosphorus tests showed a value less than 1 lb of available phosphorus to the acre. Potassium was adequate in all cases.

Forage and seed yield in 1964 showed much variability, due, in part, to differences in crop stand, age, and amount of grass present. Yields were low with limited response to the fertilizer treatments applied. Soil moisture during the season was critically deficient. Lime and phosphorus, each alone and in combinations, gave an increase in forage and seed yield. Significant response was obtained in 65% of the cases for lime and phosphorus. There was no measurable response to potassium or boron.

From this study and previous investigations, it is concluded that a considerable increase in birdsfoot trefoil forage and seed yield would result from reasonable applications of lime and phosphorus if applied and worked into the soil at the time of seeding. Top dressing of established stands, while of real value, cannot be fully effective in rejuvenating and rendering productive an already aged and maladitious crop.

Title: THE INFLUENCE OF COMPANION CROPS ON THE ESTABLISHMENT OF ALFALFA AND BIRDSFOOT TREFOIL SEEDINGS

Leaders: H. A. MacDonald and M. N. Bandyopadhyay

During the period 1961 to 1964 studies were conducted at Ithaca, New York, to evaluate the degree and nature of the influence of companion crops on the establishment of alfalfa and birdsfoot trefoil. Studies with and without the use of companion crops were conducted in the greenhouse and in the field. Companion crop variables included species, winter wheat, winter rye, oats, barley, sudan grass and buckwheat; varieties representing different heights and days to maturity; planting rates; nitrogen fertilization and harvest management or time of removal. Investigations in the absence of companion crops included as variables, light intensity or shading, weed control and level of available soil moisture.

All degrees of shading below an optimum for the prevailing situation reduced the establishment and seeding yield of alfalfa and birdsfoot trefoil, whether due to companion crops or artificial shading. Birdsfoot trefoil, particularly the Empire variety, was more seriously affected by low light than alfalfa. Light levels of 25% of full daylight became critical for alfalfa while Empire birdsfoot trefoil required about 50% of full daylight. Viking birdsfoot trefoil was intermediate. Response to available light was restricted at low soil moisture levels whether brought about by companion crops or other circumstances.

Establishment, as measured by seedling stand, plant vigor, growth and development or yield in the first or second year, was directly related to light availability and influenced by soil moisture. The restrictive influence companion crop was reduced by using one of limited total growth or yield,

short straw, limited leafiness, and short growing season. Stand establishment was further improved by thin seeding of the companion crop and its removal or harvest not later than the late heading stage. Nitrogen fertilization increased the yield of the companion crop, but resulted in increased competition, shading and lodging injury particularly in the case of the tall cereal varieties. Irrigation was helpful to the seeding in summer and early autumn of most years. Weed control benefited the seeding, but the use of a companion crop as a weed control technique merely replaced one competitive force with another. The weed factor was variable with species as to effect and time. Sudden removal of dense shade late in the growing period during periods of high temperature, bright sunshine and low soil moisture and humidity proved to be disastrous to the weakened seedling.

In all cases birdsfoot trefoil was more seriously affected by companion crop competition than alfalfa in the order: Empire birdsfoot trefoil > Viking birdsfoot trefoil, > Vernal alfalfa > DuPuits alfalfa.

Title: BIRDSFOOT TREFOIL INSECT INVESTIGATIONS

Leaders: G. K. Morris and G. G. Gyrisco

A Tettigoniid, Metrioptera roeseli introduced from Europe in 1952 by way of Montreal, Canada, in 1952 has established itself in Central New York in large numbers in hay fields, especially birdsfoot trefoil fields. These long horned grasshoppers have strigulatory organs and sing. Frequency analyses were made of the sounds produced by M. roeseli and other related long-horned grasshoppers during the summer of 1964. These insects were found to establish territories using their sound producing organs to advertise their territories. Research demonstrated the existence of a band of ultrasonic frequencies and various other experiments indicated the role of specialized areas of the wind as resonators in the production of sound.

Plant bugs, particularly tarnished plant bugs, were found to be causing extensive blossom drop in a field of Viking trefoil in Cayuga County. Here HRS 1671 gave good control of the nymphs while Bayer 41831 and Bayer 52160 showed some promise for this use.

In a second field experiment, GS 12968, Bayer 37289, Bayer 25141 and Cygon at 1.5, 1, 1, and 0.5 lb/acre of actual toxicant gave control of the tarnished plant bug comparable to endrin at 1.0 lb.

Title: RESISTANCE OF SEVERAL SPECIES OF FORAGE CROPS TO THEIR INSECT PESTS

Leaders: E. J. Armbrust and G. G. Gyrisco

Second and third instar alfalfa weevil larvae were field collected and placed on replicated bouquets of the following alfalfa varieties: Ranger, Savana, Cayuga, DuPuits, A 2534, Syn 2-(62-50), Unita 62-48, Narragansett, Vernal, Utah Syn J 2-62-49, Cody, and Atlantic. Resistance was rated by scoring each bouquet.

None of the varieties showed any good, economic resistance to alfalfa weevil larval injury but Savana showed the least feeding although it was not significantly better in that respect than the others tested.

Using a similar technique, the following clover varieties were tested for insect resistance and scored. In order from best to worse were: Pennscott, Medium Red, Mammoth Red, Dollard, Sepa, Chesapeake, and Alta Swede. None was immune to weevil feeding. None was outstandingly resistant.

Title: BIOLOGY AND CONTROL OF THE ALFALFA WEEVIL

Leaders: E. J. Armbrust, W. R. Cothran, and G. G. Gyrisco

Alfalfa weevils were reared from newly hatched larvae through ovipositing adults in 11 photoperiod chambers giving 7-17 hours of light per 24 hours at a constant temperature of 30° C. Contrary to findings by other workers where weevils reared at less than 9-1/2 hours of photoperiod at laboratory temperatures exhibited abbreviated diapause, all colonies underwent normal diapause. This gives evidence that high temperatures will override the effects of short photoperiods.

A statewide survey of alfalfa in New York in 1964 showed the weevil to be present in 9 new counties not previously known to be infested. At this time 31 counties of New York are known to be infested with alfalfa weevils.

A number of experimental compounds were tested for alfalfa weevil control. None of these applied in the fall gave practical control of the weevil. None equaled heptachlor in control regardless when applied. None exceeded the malathion-methoxychlor mixture now recommended for control as a spring application. The following compounds were tested for weevil control: AC 47472, AC 47031, AC 52160, Banol, Bayer 37289, Bayer 41831, Bayer 25141, Cygon 267, Diazinon, Diazinon plus methoxychlor, Delnav, endrin, lindane, malathion, malathion plus methoxychlor, malathion plus Guthion, Guthion, silica gel plus Guthion, HRS 1671, HRS 1653, methoxychlor, Imidan, GS 13005, NIA 10242, UC 21149, N 2790, RP 11783, and RP 11974.

Title: FLIGHT BEHAVIOR AND CONTROL OF THE EUROPEAN CHAFER

Leaders: R. J. Little, Jr., and G. G. Gyrisco

Biology studies supported in part by NIH Grant GM 11276-02 continued the research on the role of environmental factors in the rhythmic flight of the European chafer adults. Adult chafers were subjected to air temperature gradients of $20^{\circ}\text{F} \pm 1^{\circ}$. Of the males, 37% moved to the $70^{\circ} - 75^{\circ}\text{F}$ range, 61% to $75^{\circ} - 80^{\circ}\text{F}$ range and 2% were at 80°F or above. Of the females, 48% were located at $70^{\circ} - 75^{\circ}\text{F}$, 48% at $75^{\circ} - 80^{\circ}\text{F}$ and 2% were above 80°F .

Investigations of the effects of normally fluctuating soil temperature gradients versus isothermal soil conditions on the flight of the beetles were conducted. No significant differences in flight responses were detected in field and laboratory trials.

Evening conditions were produced in a home fabricated simulator through the use of a newly devised manual and automatic electrical programming system. Flights occurred in the simulators when evening environmental conditions had been established 3, 6 and 9 hours prior to the normal time of flight. In preliminary work to determine the presence or absence of circadian rhythm in the flight behavior, a technique was found by which remote locomotory activity could be monitored.

The following relatively short residual chemicals were field tested for their effectiveness against European chafer larvae of all instars: AC 47, 031, AC 47,470, AC 47,772, Bayer 25141, Bayer 37289, HRS 1671, MC-A600, N-2790, NIA 10242, UC 10854, UC 21149 and the standard, dieldrin. Fall samplings showed HRS 1671, Bayer 25141 and Bayer 37289 to be promising at 5 lbs of actual toxicant per acre and above. AC 47,470, AC 47,031 and NIA 10242 were effective at 12 lbs of actual toxicant per acre and above. UC 10854, UC 21149, MC-A600 and N-2790 significantly reduced the larval population when applied at 20 lbs per acre.

PENNSYLVANIA

Title: THE GENETICS AND IMPROVEMENT OF PERENNIAL FORAGE LEGUMES

Leaders: R. W. Cleveland and J. L. Starling

Alfalfa

(1) Breeding alfalfa with creeping rooted character was continued in 1964. Intercross and self-pollinated progenies were produced from vigorous creeping plants selected in 1963. Seedlings of these progenies have been started in greenhouse cultures and will be evaluated for creeping rootedness in root cultures. Additional plants were selected in 1964, which will be used for progeny testing in the same manner as 1963 selections. One additional generation will be necessary for attainment of an adequate level of

creeping rootedness in the progenies. Further selection for desirable agronomic type will then be necessary.

(2) The first year's evaluations of forage yield were made for polycross progenies established in field experiment in 1963 in cooperation with the USDA. This is an effort to evaluate general combining ability and resistance to disease for 67 progenies. The results on completion may be used to formulate one or more experimental varieties similar to Vernal in adaptation but having needed disease resistance.

Red Clover

Breeding for Northern anthracnose resistance in red clover was continued. Intercross progenies of selected plants were produced in preparation for inoculation with the disease organism and reselection of resistant plants for use in producing another backcross generation.

Variety Trials

Evaluations of varieties among several species of legumes are carried out in a continuing program. Trials of red clover, alfalfa, ladino clover and birdsfoot trefoil have been established at one or more locations in Pennsylvania. New varieties are recommended for use when adequate evidence for satisfactory performance and adaptation is accumulated.

Title: CYTOGENETICS OF FORAGE CROP SPECIES AND INTERSPECIFIC HYBRIDS

Leaders: J. L. Starling and R. W. Cleveland

Trisomics of diploid alfalfa

A study of the meiotic behavior of several trisomics was completed in an MS thesis by Mr. G. R. Buss. The frequency of trivalents varied significantly among the single trisomics (17-chromosome plants), and differences were found among the plants in other meiotic occurrences. A single plant with 18 chromosomes (double trisomic) was also similarly studied, but no comparative data among 18-chromosome plants could be obtained. With the objective to identify trisomics as to the specific chromosome which each contains in three doses, the results of the present study did not offer conclusive answers, but indicated a number of possibly fruitful approaches. Continuing studies are being made under this objective. The eventual identification of all possible single trisomics in diploid alfalfa will provide a source of material for genetic studies to enable the positive identification of the specific chromosomes on which mutant genes are located.

Species hybrids in Trifolium

A continuation and extension of studies reported by J. F. Schwer (Ph. D. thesis, Pennsylvania State University, 1962) were begun. Cytological studies of hybrids involving natural diploid and tetraploid derivatives

of Trifolium pratense, T. hirtum, T. pallidum and T. diffusum are to be made. Stocks of these species have been obtained, chromosome doubled derivatives are being produced by use of colchicine treatments, and interspecific crosses attempted. The objective of this study is to ascertain the relationships among the species in chromosome homologies and to determine the possibilities for gene transfers from T. pallidum and T. hirtum to T. pratense.

Title: THE GENETICS AND IMPROVEMENT OF FORAGE GRASSES

Leaders: J. L. Starling and R. W. Cleveland

Orchardgrass Breeding

A broadcast plot trial for testing the general combining ability of 203 clonal selections was established. The parental clones were rated for maturity, seed production and disease reaction. Polycross seed was harvested for additional tests—first year's production was measured in a broadcast plot trial of 45 clonal progenies and check varieties. Parental clones had been selected for late maturity and disease resistance. At least one clone seems outstanding—breeders seed was produced for the varieties Pennlate and Pennmead. The Pennlate breeders seed nursery was reestablished at a new site and the Pennmead nursery was enlarged—a broadcast plot trial of named varieties and experimental synthetics was planted. A study of germination rates of seed from clones of varying maturities was initiated. Relationships between germination rate and other plant characteristics and clones and germination environment interactions will be studied.

Phalaris Breeding

A spaced planted nursery of plants from 11 European accessions and 5 F₁ interspecific hybrids between Phalaris arundinacea and P. tuberosa was grazed by cattle. Difference in intensity of grazing was rated. Hybrids did not appear to be more acceptable than P. arundinacea.

Tall Oatgrass

A source nursery of accessions was established. Ratings were made on vigor, heading and leafiness.

Variety Trials

Variety trials of orchardgrass, brome grass and timothy were planted at two locations. Trials of the above species and reed canarygrass were evaluated at one location.

Title: ESTABLISHMENT AND MAINTENANCE OF BIRDSFOOT TREFOIL

Leaders: J. B. Washko and S. W. Pruss

Studies on the physiological reaction of Viking and Empire birdsfoot trefoil varieties to various clipping treatments were continued in 1964. Although some of the trends were similar to those observed in 1963 the droughty weather of 1964 drastically influenced both root reserves in plant and aftermath production.

Removal of top growth at a 6-inch height (pasture stage) on May 22 caused a severe drop in root reserves by the next week. Later cuttings seemed to have less effect on reserve levels than in 1963. Forage production from this 6-inch height averaged 0.9 ton per acre for the Empire variety and 1.2 tons for the Viking variety. When these varieties were harvested at 1/2 to full bloom (hay stage) higher yields were obtained. The Viking variety produced 1.65 tons of forage per acre and Empire 1.55 tons per acre. Because of the droughty conditions aftermath yields were low.

Title: EVALUATION OF NEW FORAGE VARIETIES AND SPECIES FOR DAIRY PASTURES

Leaders: J. B. Washko, W. L. McClellan, E. M. Kesler and A. L. Haskins

The various forage species produced as follows during the third successive drought year: the Vernal alfalfa-Pennlate orchardgrass sward produced the highest yields of dry matter and had the highest carrying capacity per acre, 4.92 tons and 422 cow days of grazing per acre, respectively; next most productive was the Viking trefoil-Pennlate orchardgrass sward with 3.12 tons dry matter and 384 cow days; then, in order N-fertilized Pennlate orchardgrass with 2.32 tons and 399 cow days, ladino clover-Pennlate orchardgrass 2.11 tons and 354 cow days and Balbo rye and Piper sudangrass, double-cropped, with 2.01 tons dry matter per acre and 288 cow days of grazing, respectively. These results emphasize the value of deep rooted legumes such as alfalfa and birdsfoot trefoil in providing pasturage during droughty years.

Title: EVALUATION OF SORGHUMS, SUDANGRASS AND MILLETS FOR FIELD PRODUCTION

Leaders: J. B. Washko, J. D. Harrington and A. L. Haskins

Seventeen sudan-sorghum hybrids were tested for forage in comparison with Piper and Trudan I sudangrasses at Landisville, Centre Hall and Ligonier. Piper sudan was the lowest yielding variety at all locations. Trudan I, a true sudangrass hybrid, outyielded Piper by an average of 7.2% at all locations. The sudan-sorghum hybrids were most productive of forage. They outyielded Piper sudan by 60% and Trudan I by 49.6% over all locations.

These yields were under silage management; i.e., making the first harvest when the heads are fully emerged and taking an aftermath harvest if growth exceeded 6 inches. However, under a hay management system Piper sudan produced approximately as much forage as Trudan I and Sweet Sioux, a sudan-sorghum hybrid, at all three locations in the state.

The sudan-sorghum hybrids not only are higher yielding than Piper and Trudan I but also contain higher prussic acid (HCN) levels. All varieties of sudan-grass had higher levels of HCN at Landisville than at Centre Hall and Rector. At all locations the sudan-sorghum hybrids contained the highest amounts of HCN, Piper the lowest. HCN content of plants decreased with increases in plant height except for Piper. The second aftermath also had more prussic acid than either the first harvest or first aftermath. HCN content of sudan-grass increased threefold 24 hours after a frost compared with 15 hr before frost. Apparently frost causes the HCN content of sudangrass plants to rise, it then levels off, then decreases until at 14 days after frost it returns to its original level.

Harvest management systems also influence HCN content. Less HCN was found under simulated pasture management whereas under green chop it is intermediate and highest under hay management. Hay made from Piper sudan in 1964 would not contain dangerous levels of HCN but if made from a sudan-sorghum hybrid (SX-11) it would be in the toxic range for livestock. Rating the sudangrasses from lowest to highest in HCN, their rank would be as follows: (1) Piper, (2) Trudan I, (3) Sudan-Sorghum hybrids.

High Population Corn

Corn at populations ranging from 20,000 to 100,000 plants per acre was compared in single vs. two double rows 8 inches apart and 40-inch centers for silage purposes. Dry matter yields ranged from 5.4 to 7.0 tons per acre. Planting the same population in double rows as contrasted with single rows was of no advantage except in the 40,000 to 50,000 plant population range. As in 1963 the 1964 yields of silage were limited by drought.

The sudan-sorghum hybrids will outyield open-pollinated and hybrid sudangrasses considerably. However, since they contain higher levels of HCN they must be managed judiciously to avoid this danger to livestock. This is best accomplished by letting them grow to at least 30-inch heights, use them for pasture or green chop but not for hay. Double row planting of corn for silage appears to have merit in increasing yields unless moisture is a limiting factor.

Title: UTILIZATION OF FORAGE BY BEEF CATTLE

Leaders: J. B. Washko, P. J. Phillips, A. L. Haskins, R. C. Miller and
J. H. Ziegler

During the third successive droughty year the alfalfa-orchardgrass swards were most productive of forage followed in order by N-fertilized reed canary-grass and Viking trefoil-Pennlate orchardgrass. These 191 acres of reclaimed pastureland carried 187 animal units during May and June and 147 A. U. until November 1. Supplemental feeding, green chop and hay, were required for 67

days during the 171-day grazing season. Beef yields per acre with the supplemental feeding averaged 258 lb per acre and with the value of the feed deducted 219 lb per acre despite the drought. Cross-bred dairy-beef nursing calves (340 to 383 lb) on pasturage alone, gained 293 lb, with creep feeding 384 lb. The importance of deep rooted legumes like alfalfa and trefoil for forage production during droughts is indicated. Similarly results point out the forage potential of abandoned cropland for beef production with crossbred dairy-beef cattle that dairy farmers can use to supplement their income.

Title: MAINTENANCE FERTILIZATION OF GRASSLANDS IN PENNSYLVANIA

Leader: L. F. Marriott

Lack of sufficient moisture again limited yields of orchardgrass. However, response to top-dressed fertilizer was quite evident. Annual applications of 100 to 200 lb N, 22 lb of P and 125 lb of K per acre generally increased yields by a ton or more of dry matter. Greater response has been obtained in more favorable years.

Top-dressed limestone has been effective in reducing soil acidity resulting from the continued application of nitrogen fertilizers.

Application of NPK on a 2-year old timothy stand at Ligonier with adequate moisture showed that the highest economical rate of N included 100 lb in spring and 50 lb after the first cut. This level of N required about 125 lb K to avoid yield reduction. Late fall and early winter application of 100 lb N as NH_4NO_3 was 93 to 95% as effective as a spring application. Pelleted cow manure at 10 tons per acre was equivalent to 30 lb N as NH_4NO_3 .

VERMONT

Title: RELATION OF FERTILITY TO CROP ESTABLISHMENT AND SOIL PRODUCTIVITY

Leader: J. L. McIntosh

Data obtained from alfalfa plots established in 1962 (1963 Annual Report, page 71) and harvested the last 3 years have provided information by which valuable soil test correlations could be made. It has been possible to correlate rates of fertilizer application to soil test results and in turn correlate both of these with plot yields. These data have contributed significantly to the development of new soil testing procedures in Vermont.

Title: THE ANALYSIS OF THE NATURE OF INCOMPATIBILITY SYSTEMS IN
ZIG-ZAG CLOVER

Leader: A. Gershoy

In the continuation here of studies with T. medium (1963 Annual Report, page 72) intercrossing of F₁ siblings has revealed depressing effects of inbreeding in the inflexible outcrossing mechanism which distinguishes this system.

Title: HYBRIDIZATION STUDIES IN LOTUS

Leader: A. Gershoy

Male sterile diploids and tetraploid hybrids indicate earlier and later abortion following varying degrees of aberrant meiosis. Female sterility due to variable stages in embryo abortion accompany incidence of full male fertility (1963 Annual Report, pages 72-73).

Title: FORAGE CROP INSECTS, THEIR RELATIVE IMPORTANCE AND CONTROL

Leader: G. B. MacCollom

Populations of alfalfa weevil, Hypera postica (Gyll.) continued to increase in areas of known infestation, and to move northward. The four southernmost counties of the state are entirely infested, together with portions of Addison and Orange counties. Severe injury to 1st growth alfalfa in Bennington county was observed, where larval populations average 15-23 per sweep.

Methoxychlor malathion mixture, Diazinon, malathion, guthion and methoxychlor were evaluated at 3 locations for weevil control as sprays applied to stubble following 1st cut. Drought conditions slowed aftermath growth negating any significant yield response from treatments. Larval sweeps showed guthion effective for 14 days.

Title: FORAGE CROP VARIETY TRIALS

Leader: G. M. Wood

Variety trials of timothy, orchardgrass, and alfalfa were established in 1964. Fifteen orchardgrasses, including 3 nonheading synthetics obtained from A. Hovin, U. S. Regional Pasture Research Laboratory were included. Physiological observances for onset and end of anthesis and number of panicles produced will be made in addition to the usual agronomic yield determinations. Eleven alfalfas, including New York's creeping and multileaved types, and 12 timothys are also being evaluated.

WEST VIRGINIA

Title: ALFALFA BREEDING AND GENETIC INVESTIGATIONS

Leader: Valentin Ulrich

Seed antigen relationships of nine Medicago sativa varieties were studied by immunodiffusion and immunoelectrophoresis. With antisera, produced by injecting saline seed extracts of each of the nine cultivars, it was possible to distinguish between cultivars by their precipitin reaction in immunodiffusion plates. A scheme was developed from these data that permitted varietal identification of separate but unmarked seed lots.

A second phase of this work involved the adaption of microimmunoelectrophoretic techniques to seed antigen studies. With agar-gel slide immunoelectrophoresis 1 mg of seed antigen was fractionated into four distinct bands that were identified serologically. With disc electrophoresis, patterned after Ornstein and Davis (Disc Electrophoresis, Distillation Products Industries, Division Eastman Kodak Co., Rochester, New York), 0.3 μ g quantities of Narragansett physiological saline extracts were fractionated into six distinct protein bands.

Title: RATE AND TIME OF APPLICATION OF POTASSIUM FOR ALFALFA

Leaders: G. G. Pohlman and P. R. Henderlong

Response to K was noted at Point Pleasant on Wheeling soil where yields for 1964 were 4.30, 4.72, and 5.04 tons/acre dry matter for the 200, 300, and 400 lbs/acre available K respectively. No response was noted at either of the other two locations, one of which (Wardensville) was greatly affected by dry weather.

Total K analysis on plants shows a relationship between the amount of available K and the percent K in the plants and total K removed. Thus far no effect has been noted on stand longevity. Time of application of K has not shown any effect.

Title: THE PERFORMANCE OF SEVERAL ALFALFA VARIETIES GROWN UNDER DIFFERENT CLIMATIC CONDITIONS, WITH EMPHASIS ON THE INFLUENCE OF FALL CUTTING

Leader: G. A. Jung

Plots were harvested for the fifth consecutive year. Yields (data are being processed) will be higher than those obtained in 1963 because of more precipitation. The general trend in 1963 was that Vernal and Williamsburg were the highest yielding varieties and the early September or late October cutting managements were superior to cutting in either late September or early

October. An exception to this was the early September management at Morgantown which resulted in a severe loss of stand. One possible explanation for this was that this treatment was cut at the bud stage of growth. Supplemental studies showed that first harvest yields, from plants with considerable (30-50%) bloom in early September, were not influenced by time of fall cutting whereas first harvest yields from plants cut in the bud stage of growth (early September) were significantly lower than when cut at other times in the fall.

A comparison of fall cutting and fall grazing showed that the effect of time at which the plants were defoliated was not the same for cutting and grazing. With cutting the late October treatment was best while with grazing it was poorest. These treatments were imposed on new stands this fall to obtain results during a season with more soil moisture; the first year was very dry.

Title: BIOCHEMICAL STUDIES ON COLD-RESISTANCE OF ALFALFA

Leader: G. A. Jung

Respiration rate of alfalfa varieties differing in fall growth habit and cold hardiness was monitored throughout the fall. Varieties (Alfa, DuPuits, Narragansett, Vernal, Williamsburg) were cut at three different times, i.e., August, September, or October. The data require statistical analysis, but certain conclusions which can be made are:

1. The manner of expressing CO₂ evolution (on a dry matter or plant basis) greatly alters the conclusions drawn from the same data.
2. Respiration rate decreased as air temperature decreased during the fall.
3. CO₂ evolution expressed on the basis of dry matter resulted in marked increases in respiration rate with later cutting, but these differences were small when considered on a plant basis.
4. Ranking of varieties was variable during the fall no matter how CO₂ evolution was expressed.
5. When respiration rate was monitored over the temperature range of 0°-20°C, varietal response to temperature differed.

Title: FACTORS INFLUENCING LOSSES FROM ROOT ROTS OF FORAGE LEGUMES

Leader: Edward S. Elliott

Essentially the same spectrum of fungi has been isolated from root rot diseased alfalfa that had previously been recovered from root rot diseased red clover plants. Under field conditions, the same fungi (primarily Fusarium species) are able to attack either red clover or alfalfa.

Additional evidence indicates that stress factors such as drought and insect attack usually trigger the final and sometimes lethal spread of the pathogen in the roots of these legumes.

Laboratory and greenhouse tests showed that the degree of seedling damping-off as caused by a single fungus may not be correlated with the rapidity or degree of disease development in older plants. Thus a quick seedling test for pathogenicity does not appear to be practical. Preliminary studies are underway to determine what legume viruses are prevalent on alfalfa and red clover in this region. Virus-diseased plants are being utilized to determine whether virus infection is one of the stress factors leading to rapid root rot decline.

Title: EXPERIMENTAL STUDIES IN FORAGE CROP INSECT CONTROL - 1964

Leader: C. K. Dorsey

Experimental applications of granular and spray formulations of insecticides were made in the fall of 1963 and spring of 1964 to control the alfalfa weevil.

The fall treatments were applied October 14, 1963 and the plots were sampled on May 6, 1964. SD-4072 granular formulation at 2.0 lb gave 64.0% reduction of larvae, at 1.0 lb 62.0%, and as a spray 1.0 lb, 62.0% reduction. Dime-tilan spray, 1.0 lb, was second in effectiveness, and produced 59.0% reduction of larvae.

The spring treatments were applied April 24, 1964 and evaluations were made on May 6 (2 weeks post-treatment) and on May 14 (3 weeks post-treatment). Guthion spray at 0.75 lb showed the best 2-week post-treatment larval reduction; 73.0% American Cyanamid 47472 spray, 0.25 lb, and diazinon-methoxychlor, 0.8 + 1.6 (Alfatox) were comparable in effectiveness; each reduced larval infestations 68.0%. In the 3 weeks post-treatment period, SD-7438 spray, 1.0 lb, gave the best results, 63.0% reduction; heptachlor spray, 1.0 lb, 60.0% reduction and Guthion spray, 0.75 lb, 55.0% larval reduction.

Title: INVESTIGATIONS OF A SYNDROME RESEMBLING HYPOMAGNESEMIC TETANY
IN RUMINANTS

Leader: D. J. Horvath

The behavior of cattle turned to spring pasture has been observed in conjunction with studies of the efficacy of various procedures for providing supplemental magnesium for prevention of hypomagnesemia. A new supplement form using compressed 'range blocks' has been developed at this station.

MAINE

Title: PRODUCTIVITY OF ALFALFA SEEDINGS

Leaders: C. S. Brown and R. F. Stafford

A project (1962 Annual Report, page 42) to determine the productivity of oats-alfalfa-grass seedings was continued for the third consecutive year. Simple seedings of Narragansett alfalfa with Saratoga brome, Climax timothy, or Pennlate orchardgrass were made, with or without a companion crop of Garry oats. The seeding was made on May 12 followed by harvests on July 13 and August 31.

Early and prolonged drought was again experienced as in the 1962 and 1963 tests. Alfalfa establishment was excellent, however, even with the oats companion crop. Oats depressed alfalfa yields about 0.4 ton dry matter in the first harvest, but had little residual effect on alfalfa yields in the second harvest. The net effect of oats was to increase total forage yields for the season about 0.5 ton dry matter.

As in previous years, orchardgrass proved superior to either brome or timothy in competition with vigorous alfalfa and oats. This advantage was expressed largely in the second cut, apparently as a result of the rapid recovery of orchardgrass immediately following first harvest. Yields of orchardgrass in the second cut were 3 times those of brome or timothy.

Title: PRODUCTIVITY OF SUMMER ANNUALS

Leaders: C. S. Brown and R. F. Stafford

Several sudan-sorghum hybrids were studied in comparison with Piper sudangrass and millets in a field experiment. Two seeding dates were used, May 27 and June 26, in a split-plot design. Two harvests were taken, the first when the sudan-sorghums were approximately 40 inches in height, the second in mid-September just after first killing frost.

The response to differential seeding date was especially interesting. In spite of a cool spring the early seeding (May 27) was greatly superior to the seeding made at a "normal" time in June. The May seeding produced two full crops, in contrast to the small second crop received from the June seeding. A cool summer and relatively early fall frost probably accentuated the differences observed.

There were surprisingly little differences in yield between the various crops, with the exception of Hungarian millet which failed to produce any regrowth after harvest. A brief comparison is given below.

Table 1. Dry matter yields in two harvests at Orono, Maine in 1964.

Crop	Tons per acre	
	May 27 seeding	June 26 seeding
Hungarian millet	1.66	1.32
Japanese millet	3.77	2.33
Piper sudan	3.74	2.38
Trudan	3.73	1.78
Sudax	3.49	1.67
Grazer	3.74	1.99
Sweet Sioux	3.91	2.02

Title: FORAGE HANDLING SYSTEMS FOR DAIRY FARMS

Leader: R. J. Rowe

A flail cut-flail pickup hay harvest system has been studied for several years. Only two field operations are involved. The first is a combined cutting and conditioning operation performed with a flail type forage harvester or a flail mower-conditioner. Following swath placement, the hay crop is allowed to dry in the field until its average moisture content is between 35 and 40%. The second and final field operation consists of picking the hay up with a flail type forage harvester and placing it in a self-unloading forage wagon for transport to storage. Theoretical field capacities of approximately 4.7 tons of dry hay equivalent per hour have been measured for both field pickup and unloading into storage. On most days it was possible to harvest hay the same day as cut without raking. All hay was mow dried with unheated air. The system offers considerable potential for a low cost hay harvest system to complement a silage or haylage program on the same farm, since much of the necessary equipment could be used in both cases. This project will be terminated in 1965.

USEFUL TECHNIQUES

CONNECTICUT AGRICULTURAL EXPERIMENT STATION

Nonmechanical Fraction Collector for Column Chromatography - D.D. Wolf

Separation of sugar components in a carbohydrate fraction may offer useful clues to plant responses. After adapting procedures for successful sugar separation a dependable inexpensive fraction collector was needed. Such a device was constructed from easily obtainable lab supplies and tubing for less than \$10. Most of this expense was in test tubes used as collection vessels. Briefly, the construction involves a rubber stopper fitted with a 6-inch air vent made of 2 mm bore glass tubing and a 3 mm bore aluminum tube 2 inches long. The aluminum tube has a tapered end that can be inserted into a hole in the conducting tubing. The rubber stopper is placed in 25 x 200 mm test tubes that are supported in a long row or circle. The tapered points are inserted into a length of 1/4 inch plastic tube. The column effluent enters the plastic tube and fills the first test tube by entering the aluminum tube. When the liquid effluent touches the air vent the flow into the vessel is stopped and the effluent continues to the next adjacent collection unit.

VERMONT AGRICULTURAL EXPERIMENT STATION

A Biological Method for Studying Aeration Status of Soil in Situ

R. J. Bartlett

A method has been proposed for the evaluation of the aeration status of soil in the field as it is reflected in nitrogen transformations taking place in a standard soil. The standard soil is confined in polyethylene freezer bags, sealed and buried in the soil at the depth where testing of aeration is desired. After a period of time, e.g., 30 days, the bags are opened and the soil extracted with KCl for determination of ammonium and nitrate nitrogen. The relative amounts of the two forms will be an indication of the aeration regime that has prevailed for the period of incubation. Among the advantages of thin polyethylene are the following:

1. It serves as a substrate for only a few microorganisms.
2. Oxygen and CO₂ diffuse through readily.
3. Water vapor moves through quite slowly.
4. The rate of diffusion of most ions through this material is almost negligible.

This technique eliminates leaching and much of the sampling error usually inherent in studies involving comparative analysis of field soils.

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